

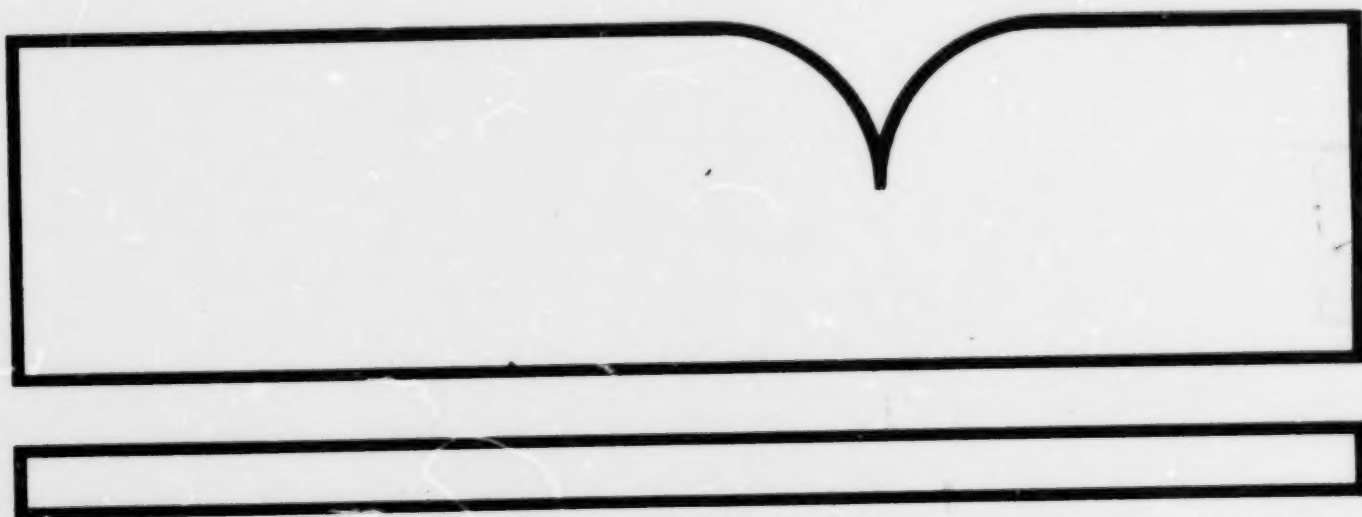
The Feasibility of a Regional Industrial
Wastewater Treatment Facility

Datagraphics, Inc.
Pittsburgh, PA

Prepared for

Robert S. Kerr Environmental Research Lab.
Ada, OK

Apr 80



United States
Environmental Protection
Agency

Robert S. Kerr Environmental Research
Laboratory
Ada OK 74820

EPA-600/2-80-065
April 1980

Research and Development

pb80-195757



The Feasibility of a Regional Industrial Wastewater Treatment Facility

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TECHNICAL REPORT DATA
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1. REPORT NO. EPA-600/2-80-065		2.		3. RECIPIENT'S ACCESSION NO. PB 80 195787	
4. TITLE AND SUBTITLE The Feasibility of a Regional Industrial Wastewater Treatment Facility				5. REPORT DATE April 1980 issuing date	
				6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) Henry C. Bramer Charles A. Caswell				8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Datagraphics, Incorporated 501 Castle Shannon Boulevard Pittsburgh, PA 15234				10. PROGRAM ELEMENT NO. 1BB610	
				11. CONTRACT/GRANT NO. Grant No. R804182	
12. SPONSORING AGENCY NAME AND ADDRESS Robert S. Kerr Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Ada, OK 74820				13. TYPE OF REPORT AND PERIOD COVERED final 12/8/75 - 11/30/78	
				14. SPONSORING AGENCY CODE EPA/600/015	
15. SUPPLEMENTARY NOTES					
16. ABSTRACT The feasibility of establishing a regional industrial wastewater treatment (RWT) facility to serve the 68 industrial plants along the lower reaches of the Monogahela River has been studied. It has been concluded that a facility consisting of an interceptor sewer system following the river course with a treatment plant near the point at Pittsburgh is technically possible. The facility would best be designed to treat up to 568,000 cubic meters per day (cu m/day) (150 million gallons per day (mgd)) of wastewater. Several obstacles to the implementation of such a concept exist. The fact that effluent guidelines are not in effect preclude precise determination of the RWT treatment requirements at this time. Previously published best available treatment economically achievable (BATEA) limitations would require a degree of treatment not clearly demonstrated. It must therefore be concluded that an RWT facility in this geographical area is technically possible, but would be neither economically nor institutionally feasible.					
17. KEY WORDS AND DOCUMENT ANALYSIS					
a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS		c. COSATI Field/Group	
Activated Sludge Process Activated Carbon Treatment Interceptions (Sewers) Filtration		Regional Treatment Facility Industrial Wastewater Mutant Bacteria Wet Air Oxidation		68D	
18. DISTRIBUTION STATEMENT Release to Public		19. SECURITY CLASS (This Report) Unclassified		21. NO. OF PAGES 77	
		20. SECURITY CLASS (This page) Unclassified		22. PRICE	

EPA-600/2-80-065
April 1980

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TREATMENT FACILITY

by

Henry C. Bramer
Charles A. Caswell
Datagraphics, Incorporated
501 Castle Shannon Boulevard
Pittsburgh, Pennsylvania 15234

Grant No. R804182

Project Officer

Thomas E. Short
Source Management Branch
Robert S. Kerr Environmental Research Laboratory
Ada, Oklahoma 74820

ROBERT S. KERR ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U. S. ENVIRONMENTAL PROTECTION AGENCY
ADA, OKLAHOMA 74820

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FOREWORD

The Environmental Protection Agency was established to coordinate administration of the major Federal programs designed to protect the quality of our environment.

An important part of the Agency's effort involves the search for information about environmental problems, management techniques and new technologies through which optimum use of the Nation's land and water resources can be assured and the threat pollution poses to the welfare of the American people can be minimized. EPA's Office of Research and Development conducts this search through a nationwide network of research facilities.

As one of these facilities, the Robert S. Kerr Environmental Research Laboratory is responsible for the management of programs to: (a) investigate the nature, transport, fate and management of pollutants in ground water; (b) develop and demonstrate methods for treating wastewaters with soil and other natural systems; (c) develop and demonstrate pollution control technologies for irrigation return flows; (d) develop and demonstrate pollution control technologies for animal production wastes; (e) develop and demonstrate technologies to prevent, control, or abate pollution from the petroleum refining and petrochemical industries; and (f) develop and demonstrate technologies to manage pollution resulting from combinations of industrial wastewaters or industrial/municipal wastewaters.

This report is a study of the feasibility of establishing a regional wastewater treatment facility to serve the industrial complex of the lower Monongahela River. Such regional facilities are relatively rare in the United States although they are quite common in European countries. These facilities frequently offer technological and wastewater management advantages in addition to economies-of-scale. The conclusions illustrate that technological feasibility alone is insufficient impetus to effect construction of such facilities; in the study area, institutional factors are a barrier to further consideration of a regional facility at this time.

William C. Galegar

W. C. Galegar
Director

Robert S. Kerr Environmental Research Laboratory

ABSTRACT

The feasibility of establishing a regional industrial wastewater treatment (RWT) facility to serve the 68 industrial plants along the lower reaches of the Monongahela River has been studied. It has been concluded that a facility consisting of an interceptor sewer system following the river course with a treatment plant near the point at Pittsburgh is technically possible. The facility would best be designed to treat up to 568,000 cubic meters per day (cu m/day) (150 million gallons per day (mgd)) of wastewater consisting of 10% of the presently discharged process water and 10% of the presently discharged unsegregated, non-contact cooling water. The construction and operation would be best handled by the Allegheny County Sanitary Authority (ALCOSAN) and funded by revenue bonds backed by long-term contracts from industrial users.

Several obstacles to the implementation of such a concept exist. The fact that effluent guidelines are not in effect preclude precise determination of the RWT treatment requirements at this time. Previously published best available treatment economically achievable (BATEA) limitations would require a degree of treatment not clearly demonstrated. Industry representatives have not supported the concept and have given cost and unwillingness to make the necessary long-term commitments as the main reasons for this opposition. The hope of industry for relaxed BATEA limitations may well be another reason.

It must therefore be concluded that an RWT facility in this geographical area is technically possible, but would be neither economically nor institutionally feasible.

This report was submitted in fulfillment of grant no. R804182 by Datagraphics, Incorporated, under the sponsorship of the U. S. Environmental Protection Agency. This report covers a period from December 8, 1975 to November 30, 1978 and work was completed as of November 30, 1978.

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SECTION 1

INTRODUCTION

Regional industrial waste treatment facilities would be expected to minimize the costs of industrial pollution abatement through economies-of-scale if nothing else. The concept is analogous to the widespread applications to municipal/industrial wastes such as are exemplified by the Allegheny County (Pennsylvania) Sanitary Authority (ALCOSAN) and the Metropolitan Sanitary District of Greater Chicago. The concept is embodied, in large measure, in the Genossenschaften (Cooperative Associations of the Ruhr Valley in Germany), but is not implemented now in the United States. It was the purpose of this study to determine the technological and economic feasibility of establishing a regional industrial waste treatment facility in a significantly large area wherein the factors involved are of sufficient complexity to warrant generalization from the data developed.

This study has intended to accomplish this objective by a comprehensive analysis of the feasibility of such a facility (or facilities) in the highly industrialized lower reaches of the Monongahela River near Pittsburgh, Allegheny County, Pennsylvania. A major emphasis in this study is the incorporation of technologically innovative concepts with the objective of obtaining treatment levels equal to or better than best available technology economically achievable (BATEA). Such concepts should be feasible for a regional facility, whereas individual plants may not be able to implement such concepts lacking the economies-of-scale, sufficient financial or other resources or simply sufficient recoverable material to be worthwhile. The project was intended to provide the following end-products:

1. A proposed plan of facilities to treat, recover, and/or dispose of industrial wastes to or beyond the degree required by current and anticipated national and local regulations.
2. A method for financing these facilities at modest or zero cost to government and at the least cost to industry.

3. The method for accomplishing the proposed plan so that construction would be completed within five years following the study.
4. An interim system, such as mobile plants, that could provide significant improvements during the design and construction period.
5. Comparisons of the efficiency and cost-effectiveness of the regional system vis-a-vis the individual plant treatment system.

There are some 68 industrial plants along the lower eighty kilometers (fifty miles) of the Monongahela River which are potential dischargers to the centralized industrial wastewater treatment facility. The present discharges from these 68 plants average 5,761,000 cu m/day (1,522 mgd) with maximum reported discharges of 7,055,000 cu m/day (1,864 mgd). Eleven of these plants discharge an average of 5,700,000 cu m/day (1,506 mgd) while the remaining 57 plants discharge an average of 62,100 cu m/day (16.4 mgd). All but 378,500 cu m/day (100 mgd) of the present average discharges originate in the lower 36.2 kilometers (22.5 miles) of the river. It was originally intended that the RWT facility would serve only those plants in the lower 40.2 kilometers (25 miles) reach of the Monongahela River, i.e., within Allegheny County.

There is, however, no good reason for this limitation, and the study has therefore included the 68 plants within 80 kilometers (50 miles) of the confluence of the Monongahela and Allegheny Rivers as described above.

Table 1 shows the present industrial plant discharges from the 68 plants under consideration in terms of average and maximum flows and loads of total suspended solids, oil, iron, ammonia, and biochemical oxygen demand (BOD). The differences between average and maximum discharges point out rather clearly the major problem with the use of industrial process water on a once-through basis with terminal treatment facilities, i.e. the problem of slug discharges due to equipment malfunction, accidental spills, etc. This is most clearly shown in the case of oil discharges which average about 27,200 kilograms per day (kg/day) (60,000 lbs/day) but range up to 318,000 kg/day (700,000 lbs/day) at a maximum. In Table 2, the numbers and types of plants according to the 2-digit Standard Industrial Code (SIC) classifications are shown. Although there are many different types of industrial plants in the region under consideration, all of the 11 large plants are in SIC group 3312, blast furnaces and steel plants. This, of course, reflects the fact that Pittsburgh is a major steel producing center.

TABLE 1. PRESENT INDUSTRIAL PLANT DISCHARGES (METRIC UNITS)

Parameter	57 plant total		11 plant total		68 plant total	
	average	maximum	average	maximum	average	maximum
Flow, cu m/day	62,074	101,060	5,700,210	6,953,045	5,760,770	7,055,240
T.S.S., kg/day	14,197	21,229	84,248	209,409	98,445	230,638
Oil, kg/day	351	648	26,638	316,877	26,988	317,525
Iron, kg/day	182	216	4,422	6,978	4,604	7,194
NH ₃ N, kg/day	16.1	27.8	4,375	9,738	4,391	9,766
BOD, kg/day	194	515	6,063	6,063	6,257	6,578

TABLE 1. PRESENT INDUSTRIAL PLANT DISCHARGES (ENGLISH UNITS)

Parameter	57 plant total		11 plant total		68 plant total	
	average	maximum	average	maximum	average	maximum
Flow, mgd	16.4	26.7	1,506	1,837	1,522	1,864
TSS, #/day	31,270	46,759	185,569	461,254	216,839	508,013
Oil, #/day	773	1,428	58,673	697,967	59,446	699,395
Iron, #/day	401	476	9,739	15,730	10,140	15,846
NH ₃ N, #/day	35.4	61.2	9,636	21,450	9,671	21,511
BOD, #/day	428	1,135	13,355	13,355	13,783	14,490

TABLE 2. INDUSTRIAL PLANTS BY SIC CLASSIFICATION

S.I.C. no.	Industrial classification	No. of plants
12	Bituminous Coal and Lignite Mining	5
15	Building Construction - General Contractors	1
20	Food and Kindred Products	2
28	Chemicals and Allied Products	6
29	Petroleum Refining and Related Industries	2
32	Stone, Clay, Glass, and Concrete Products	4
33	Primary Metal Industries	30
34	Fabricated Metal Products Except Ordnance, Machinery and Transportation Equipment	4
35	Machinery Except Electrical	3
40	Railroad Transportation	5
41	Local and Suburban Transit and Interurban Passenger Transportation	1
50	Wholesale Trade	2
51	Unknown (probably an error in designation)	1
89	Miscellaneous Services	2

SECTION 2

CONCLUSIONS

1. A RWT facility is technically feasible in a region such as the lower reaches of the Monongahela River, i.e., a downstream central treatment facility served by an interceptor sewer following the river and receiving 568,000 cu m/day (150 mgd) of wastewater from 68 industrial plants.
2. The principal deterrent to the implementation of such a system at the present time lies in the regulations on effluent limitation for National Pollutant Discharge Elimination System (NPDES) permits. Most regulations for effluent limitations have been remanded to EPA for study, and the design of an RWT facility cannot now be finalized.
3. Industry hopes that the effluent limitations will be relaxed from those previously promulgated, and apparently is loath to support in any way a demonstration that would indicate that those limitations are attainable.
4. In a region such as the lower Monongahela where a parallel regional municipal treatment system is operated by a municipal authority, the most likely institutional arrangement would be the construction and operation by that same authority as a departmental operation, financed by revenue bonds based upon long-term contracts with the industrial users.
5. Industry representatives have indicated that in-plant treatment to BATEA limitations would be less costly, that a long-term commitment is unacceptable, that it is not acceptable to relinquish "control" to an "outside" organization, and that other benefits are either not important or are overshadowed by cost considerations.
6. The study has demonstrated a methodology by which a RWT facility may be planned and has shown the problems involved. In other locations the concept might be implemented, particularly where industry may have different attitudes, lower wastewater volumes, and different kinds of effluent pollutants; where the terrain may be more hospitable; and where plants are closer together.

SECTION 3

RECOMMENDATIONS

This study has shown that the widely held belief that central treatment plants are desirable because of economies-of-scale advantages is not always correct. Industry representatives have, in the past, favored the RWT facility concept in the study area, but are now completely opposed to it.

This report outlines the many problems associated with the implementation of the RWT facility concept. It may well be that the concept could be implemented in other locations where industry may have different attitudes, where industries may have lower wastewater volumes and more similar effluent pollutants, where the terrain may be more hospitable, and where plants are closer together.

A limited distribution of this report is recommended to those who may contemplate the RWT facility concept in more likely circumstances. The methodology used in this study is sound, and the methodology could well be applied to other geographical areas and other mixes of industrial plants.

SECTION 4

INVENTORY OF INDUSTRIAL PLANTS AND EXISTING DISCHARGES

An inventory of the industrial plants along the Monongahela River which might be served by the RWT facility was prepared on the basis of data in the "Industrial Facility Inventory" for Area 9 from the Pennsylvania Comprehensive Water Quality Management Plan (COWAMP) study, indicated plants on the Corps of Engineer Navigation Maps for the Monongahela River, NPDES permit applications, NPDES permits, and reports prepared for use in adjudicatory hearings held to hear appeals of Pennsylvania certifications of NPDES permits.

From the COWAMP data, Table 3 was prepared which shows the average discharges by kilometerpoint (milepoint) up the Monongahela for 56 plants. Detailed examination of the data available for each plant showed that of the 5,030,000 cu m/day (1,329 mgd) total, 1,272,000 cu m/day is non-contact cooling water discharged from separate outfalls, i.e., segregated from and unmixed with process water. For those plants not in the COWAMP inventory, discharge volumes were assumed to be the average per plant in each SIC category as in the COWAMP data.

From the COWAMP data, loads of discharged pollutants were tabulated for the 24 smaller plants for which data were available. Loads of pollutants from each of the other 33 smaller plants were assumed to be the averages of the 24. The data of Table 4 summarize the estimated discharges from the 57 smallest plants. Only for boron and chemical oxygen demand (COD) were the 24-plant averages not used due to the exceptionally high one-plant values.

For the other 11 plants, all in SIC 3312 and the largest of the 68 total, more detailed data were available. The production capacities of these plants are shown in Table 5 by types of production facilities. In Table 6, the discharges from these 11 plants are shown as reported from the various effluent data sources. Other constituents were estimated on the basis of the level "A" discharges in the EPA Effluent Guidelines Development Documents according to production capacity. The reported level "A" discharges were also used to check, and in some cases correct, the reported plant discharges. For the 68 plants likely to be served by a RWT facility, present estimated average and maximum discharges are as shown in Tables 6 and 7.

TABLE 3. COWAMP PLANTS AND DISCHARGES UP TO THE MONONGAHELA RIVER

Monongahela River kilometers	Discharges cu m/day	Cumulative discharge cu m/day	Number plants	Cumulative no. of plants
0.0-1.3	1.5	1.5	1	1
1.3-7.2	1250322.8	1250323.3	2	3
7.2-8.4	408.8	1250732.1	3	6
8.4-8.8	3378.1	1254110.2	3	9
8.8-11.9	26.5	1254136.7	1	10
11.9-15.3	493488.3	1747525.0	2	12
15.3-16.6	83.3	1747708.3	1	13
16.6-19.0	681300.0	2429008.3	6	19
19.0-19.3	889096.5	3318104.8	1	20
19.3-22.2	1578.3	3319683.1	2	22
22.2-24.1	493564.0	3813247.1	2	24
24.1-24.9	374098.0	4187324.1	3	27
24.9-26.1	106.4	4187451.5	3	30
26.1-26.4	821.3	4188272.8	5	35
26.4-29.8	4428.4	4192701.3	1	36
29.8-32.2	1964.4	4194665.7	1	37
32.2-36.5	504233.9	4698899.6	6	43
36.5-37.7	1517.8	4700417.4	4	47
37.7-47.5	132.5	4700549.9	1	48
47.5-48.9	1059.8	4701609.7	1	49
48.9-49.4	56.8	4701666.5	1	50
49.4-57.6	185.5	4701852.0	1	51
57.6-69.2	197312.1	4899164.1	2	53
69.2-70.3	10106.0	4909270.1	1	54
70.3-75.6	121877.0	5031147.1	2	56

TABLE 4. ESTIMATED TOTAL DISCHARGES FROM THE 57 SMALLEST PLANTS

Parameter	24 plant total		no. of plants	Average per plant		57 plant total	
	average	maximum		average	maximum	average	maximum
Flow, cu m/day	26,098	42,600	24	1087	1775	61,959	101,175
T.S.S. kg/day	5,522	8,254	21	263	393	14,197	21,229
SO ₄ , kg/day	1,174	7,723	9	130	849	5,474	7,891
TDS, kg/day	2,508	5,446	10	251	545	10,793	23,425
Phenol kg/day	0.040	0.048	1	0.040	0.048	1.34	1.62
B, kg/day	130	159	3	43.4	53.1	130	159
BOD, kg/day	89.4	129	11	4.42	11.7	194	515
MBAS, kg/day	1.64	2.00	4	0.41	0.50	15.1	18.5
F, kg/day	14.9	18.6	4	3.74	4.63	138	172
Mg, kg/day	89.4	119	5	17.9	23.9	680	908
O/G, kg/day	75.4	139	9	8.35	15.4	351	648
Al, kg/day	2.95	4.12	2	1.48	2.06	51.8	72.2
COD, kg/day	271	13463	2	136	6731	271	13463
Cr, kg/day	0.10	0.14	1	0.10	0.14	3.24	4.77
NO ₃ , kg/day	0.06	0.10	1	0.06	0.10	2.01	2.55
Fe, kg/day	5.36	6.36	1	5.36	6.36	182	216
P, kg/day	3.31	3.95	4	0.83	0.99	30.6	36.6
Cl, kg/day	36.8	44.2	1	36.8	44.2	1252	1502
Zn, kg/day	0.79	0.95	1	0.79	0.95	26.9	32.3
Zn, kg/day	0.10	0.12	1	0.10	0.12	3.40	4.01
NH ₃ , kg/day	0.47	0.82	1	0.47	0.82	16.1	27.8

TABLE 5. PRODUCTION CAPACITIES OF LARGE PLANTS

Production facility	Capacity, kkg/day	Capacity, tons/day
Coke Plants	27,648	30,483
Iron Blast Furnaces	31,271	34,477
FeMn Blast Furnaces	454	501
Sinter Plants	10,938	12,059
B.O.F.	18,837	20,769
Open Hearths	17,283	19,055
Primary Mills	35,978	39,667
Section	16,421	18,105
Strip Mills	12,112	13,354
Plate Mills	7,904	8,714
Pipe/Tube Mills	5,564	6,135
Cold Rolling	13,317	14,683
Continuous Pickling	12,762	14,071
Batch Pickling	6,014	6,631
Terne/Galvanizing	1,509	1,664
Plating	1,935	2,133

TABLE 6. AVERAGE DISCHARGES FOR MONONGAHELA PLANTS

Parameter	57 smallest plants	11 largest plants	68 plant total
Flow, cu m.day (mgd)	61,998	5,700,000 (1506)	5,761,000 (1522)
TSS, kg/day (lbs/day)	14,197	84,248 (185569)	98,445 (216839)
SO ₄ , kg/day (lbs/day)	5,474	16,837 (37087)	22,312 (49145)
TDS, kg/day (lbs/day)	10,793	-	10,793 (23774)
Phenol, kg/day (lbs/d)	1.34	234 (516)	236 (519)
B, kg/day (lbs/day)	130	-	130 (287)
BOD, kg/day (lbs/day)	194	6,063 (13355)	6,257 (13783)
MBAS., kg/day (lbs/day)	15.1	-	15.1 (33.3)
F, kg/day (lbs/day)	138	2,625 (5783)	2,763 (6087)
Mg, kg/day (lbs/day)	680	-	680 (1497)
O/G, kg/day (lbs/day)	351	26,638 (58673)	26,988 (59446)
Al, kg/day (lbs/day)	51.8	-	51.8 (114)
COD, kg/day (lbs/day)	271	-	271. (597)
Cr, kg/day (lbs/day)	3.24	1,180 (2600)	1,184 (2607)
NO ₃ , kg/day (lbs/day)	2.01	2,192 (4828)	2,194 (4832)
Fe, kg/day (lbs/day)	182	4,432 (9739)	4,604 (10140)
P, kg/day (lbs/day)	30.6	-	30.6 (67.3)
Cu, kg/day (lbs/day)	1,252	-	1,252 (2757)
Cl, kg/day (lbs/day)	26.9	26,707 (58827)	26,734 (58886)
Zn, kg/day (lbs/day)	3.40	10,515 (23162)	10,519 (23169)
NH ₃ , kg/day (lbs/day)	16.1	4,375 (9636)	4,391 (9671)
CN, kg/day (lbs/day)	-	878 (1935)	878 (1935)
CNA, kg/day (lbs/day)	-	630 (1387)	630 (1387)
Sulfide, kg/day (lbs/day)	-	3,795 (8358)	3,795 (8358)
Lead, kg/day (lbs/day)	-	30.4 (67)	30.4 (67)
Manganese kg/day (lbs/day)	-	127 (279)	127 (279)
Cr+6, kg/day (lbs/day)	-	697 (1536)	697 (1536)
Tin, kg/day (lbs/day)	-	1,091 (2403)	1,091 (2403)

TABLE 7. MAXIMUM DISCHARGES FOR MONONGAHELA PLANTS

Parameter	57 smallest plants	11 largest plants	68 plant total
Flow, cu m/day (mgd)	101,200 (26.73)	6,953,000 (1837)	7,055,000 (1864)
TSS, kg/day (lbs/day)	21,229 (46759)	209,409 (461254)	230,638 (508013)
SO ₄ , kg/day (lbs/day)	36,039 (79381)	19,029 (41913)	55,067 (121294)
TDS, kg/day (lbs/day)	23,425 (51596)	-	23,425 (51596)
Phenol, kg/day (lbs/day)	1.62 (3.57)	485 (1069)	487 (1073)
B, kg/day (lbs/day)	159 (351)	-	159 (351)
BOD, kg/day (lbs/day)	515 (1135)	6,063 (13355)	6,578 (14490)
MBAS., kg/day (lbs/day)	18.5 (40.7)	-	18.5 (40.7)
F, kg/day (lbs/day)	172 (378)	2,625 (5783)	2,797 (6161)
Mg, kg/day (lbs/day)	908 (1999)	-	908 (1999)
O/G, kg/day (lbs/day)	648 (1428)	316,877 (697967)	317,525 (700011)
Al, kg/day (lbs/day)	72.2 (159)	-	72.2 (159)
COD, kg/day (lbs/day)	13,463 (29654)	-	13,463 (29654)
Cr, kg/day (lbs/day)	4.76 (10.5)	1,180 (2600)	1,185 (2611)
NO ₃ , kg/day (lbs/day)	3.55 (7.02)	2,192 (4828)	2,196 (4836)
Fe, kg/day (lbs/day)	216 (476)	6,978 (15370)	7,194 (15846)
P, kg/day (lbs/day)	36.6 (80.7)	-	36.6 (80.7)
Cu, kg/day (lbs/day)	1,502 (3300)	-	1,502 (3300)
Cl, kg/day (lbs/day)	32.2 (71.1)	28,328 (62396)	28,360 (62467)
Zn, kg/day (lbs/day)	4.01 (8.84)	10,516 (23162)	10,520 (23171)
NH ₃ , kg/day (lbs/day)	27.8 (61.2)	9,738 (21450)	9,766 (21511)
CN, kg/day (lbs/day)	-	3,434 (7564)	3,434 (7564)
CNA, kg/day (lbs/day)	-	1,894 (4172)	1,894 (4172)
Sulfide	-	3,795 (8358)	3,795 (8358)
Lead, kg/day (lbs/day)	-	30.4 (67)	30.4 (67)
Manganese, kg/day (lbs/day)	-	127 (279)	127 (279)
Cr+6, kg/day (lbs/day)	-	697 (1536)	697 (1536)
Tin, kg/day (lbs/day)	-	1,091 (2403)	1,091 (2403)

SECTION 5

RWT FACILITY INFLUENT LOADS AND REQUIRED EFFLUENT

It is not possible at this time to say exactly what the required treatment in an RWT facility would be. Most effluent guidelines previously promulgated have been remanded for further study. Under present law as interpreted by regulations, any RWT facility could discharge only the total of the BATEA loads allotted each of the 68 plants after 1983. Best practicable control technology currently available (BPCTCA) limitations apply until 1983.

Assuming that this will remain the requirement and that the guidelines for the steel industry will remain as those previously published, raw waste loads, BPCTCA limits, and BATEA limits for steel industry operations were taken from the EPA Effluent Guideline Development Documents. The limitations given therein were modified for hot rolling operations to conform with the regulations published in the Federal Register. Additionally, the data for plating operations were taken from the draft contractor's report, because this category was not included in the final development document, and the effluent data for the Clairton Coke Plant were taken from data submitted in connection with the Department of Environmental Resources (DER) Adjudicatory Hearings.

On the basis of the above data and the production data of Table 5, the total loads and discharges per BPCTCA and BATEA for the Monongahela Valley steel mills are summarized in Table 8.

TABLE 8. STEEL MILL BPCTCA AND BATEA DISCHARGES

Constituent	RWT Influent		RWT Effluent	
	"BPCTCA discharge"		"BATEA discharge"	
Flow, cu m/day (mgd)	850,900	(224.8)	115,500	(30.52)
TSS, kg/day (lbs/day)	11,832	(26061)	1,720	(3789)
O/G, kg/day (lbs/day)	8,435	(18580)	907	(1997)
Ammonia, kg/day (lbs/day)	4,662	(10268)	283	(623)
Phenol, kg/day (lbs/day)	108	(238)	14.1	(31.)
Cyanide, kg/day (lbs/day)	878	(1933)	9.1	(20)
BOD ₅ , kg/day (lbs/day)	3,032	(6679)	231	(509)
Sulfide, kg/day (lbs/day)	360	(794)	9.1	(20)
Fluoride, kg/day (lbs/day)	1,325	(2918)	523	(1152)
Manganese, kg/day (lbs/day)	11.4	(25)	4.2	(9.2)
Nitrate, kg/day (lbs/day)	607	(1337)	179	(395)
Zinc, kg/day (lbs/day)	95	(210)	20.0	(44)
Lead, kg/day (lbs/day)	5.2	(11.5)	1.1	(2.5)
Diss. Fe. kg/day (lbs/day)	40.2	(88.5)	26.3	(57.9)
Tin, kg/day (lbs/day)	68.6	(151)	10.4	(23)
Cr, kg/day (lbs/day)	41.3	(91)	1.0	(2.1)
Cr+6, kg/day (lbs/day)	0.4	(0.8)	0.06	(0.14)

For the smaller plants, the BPCTCA and BATEA limitations may be adequately estimated on the basis of once-through flow for BPCTCA and 90% recycling for BATEA with minimum effluent concentrations as used in the Steel Industry Guidelines. The limitations on these bases would be as shown in Table 9.

TABLE 9. SMALL PLANTS BPCTCA AND BATEA DISCHARGES

Constituent	RWT Influent			RWT Effluent		
	BPCTCA: FLOW = 62,000			BATEA: FLOW = 6,200		
	cu m/day (16.38 mgd)			cu m/day (1.64 mgd)		
	Conc., mg/l	Load kg/day lbs/day		Conc., mg/l	Load kg/day lbs/day	
TSS	10	620	1,366	10	62.2	137
O/G	10	620	1,366	10	62.2	137
Cr	3.0	186	410	0.1	0.64	1.4
Cr+6	0.02	1.23	2.7	0.005	0.03	0.07
Lead	0.20	12.3	27.	0.1	0.64	1.4
Tin	5.0	310	683	1.0	6.4	14
CN	0.5	30.9	68	0.25	1.54	3.4
NH ₃	125	7,750	17,070	10	62.2	137
Phenol	2.0	124	273	0.5	3.1	6.8

(continued)

TABLE 9. (continued)

Constituent	RWT Influent			RWT Effluent		
	BPCTCA: FLOW = 62,000			BATEA: FLOW = 6,200		
	cu m/day (16.38 mgd)			cu m/day (1.64 mgd)		
	Conc.,	Load		Conc.,	Load	
	mg/l	kg/day	lbs/day	mg/l	kg/day	lbs/day
BOD ₅	150	9,300	20,484	20	124	273
Sulfide	6	372	819	0.3	1.9	4.1
Fluoride	40	2,480	5,462	20	124	273
Manganese	10	620	1,366	5	30.9	68
Nitrate	150	9,300	20,484	45	279	615
Zinc	5	310	683	2	12.3	27
Diss. Fe	1	62.2	137	0	0	

Combining the data of Tables 8 and 9, the total BPCTCA and BATEA discharges for the 68 large and small plants are as shown in Table 10.

TABLE 10. BPCTCA AND BATEA DISCHARGES FOR 68 PLANTS

	RWT Influent		RWT Effluent	
	BPCTCA discharge		BATEA discharge	
Flow, cu m/day (mgd)	912,870	(241.18)	121,725	(32.16)
TSS, kg/day (lbs/day)	12,452	(27427)	1,782	(3926)
O/G, kg/day (lbs/day)	9,055	(19946)	969	(2134)
Ammonia, kg/day (lbs/day)	12,411	(27338)	345	(760)
Phenol, kg/day (lbs/day)	232	(511)	76.3	(168)
Cyanide, kg/day (lbs/day)	908	(2001)	10.6	(23.4)
BOD ₅ , kg/day (lbs/day)	12,332	(27163)	355	(782)
Sulfide, kg/day (lbs/day)	732	(1614)	10.9	(24.1)
Fluoride, kg/day (lbs/day)	3,805	(8300)	647	(1425)
Manganese, kg/day (lbs/day)	632	(1391)	35.0	(77.2)
Nitrate, kg/day (lbs/day)	9,907	(21821)	459	(1010)
Zinc, kg/day (lbs/day)	405	(893)	32.2	(71)
Lead, kg/day (lbs/day)	17.5	(38.5)	1.78	(3.9)
Diss. Fe, kg/day (lbs/day)	102.4	(225.5)	26.3	(57.9)
Tin, kg/day (lbs/day)	378.6	(834)	16.8	(37.)
Cr, kg/day (lbs/day)	227	(501)	1.59	(3.5)
Cr ⁺⁶ , kg/day (lbs/day)	1.59	(3.5)	0.10	(0.21)

SECTION 6

TREATMENT PLANT DESIGN ALTERNATIVES

The consideration of treatment plant design was preceded by a survey of those treatment facilities analogous in any way to the proposed Monongahela facility. The facilities or proposed treatment models which appeared to be likely of application here are described in this section.

There are many types of joint municipal/industrial wastewater treatment and water reuse projects in the United States. Many municipal sewage treatment plants accept and treat large industrial wastewater flows. The Metropolitan Sanitary District of Greater Chicago (Illinois) probably receives more industrial discharges in terms of both numbers of industries and volume of flow than any other United States sanitary system, and has entire engineering and chemical staffs in a separate industrial wastewater control department. The much smaller Metropolitan Sanitary District of East Chicago (Indiana) accepts and treats all of the coke plant wastes from two large steel mills (Inland Steel and Youngstown Sheet and Tube). Many other municipal plants likewise accept and treat relatively lesser volumes of industrial wastewaters.

Several municipal sewage treatment plants and their treated effluents to industrial users. The largest and most often cited example is that of the Bethlehem Steel Corporation plant at Sparrows Point, Maryland, which uses 643,500 cu m/day (170 mgd) of the treated effluent of the City of Baltimore Sewage Treatment Plant. There are 13 or more similar arrangements in the United States, most of which are in the southwest, with one in Michigan. In foreign countries, there are industrial users of treated municipal wastewaters in England, Israel, Japan, Mexico, and South Africa. Other municipal sewage treatment plant effluents are used for agricultural supplies, groundwater recharge, and recreational uses (59).

There are, however, very few RWT facilities in the United States, excluding contract waste haulers who generally treat and/or dispose of high-strength wastes such as spent pickling solutions and plating solutions. The Core Petrochemical Complex in Puerto Rico (a joint venture of Phillips Puerto Rico Industrial Development Corporation) utilizes a centralized facility to treat the wastewaters from the basic petrochemical plant and satellite facilities

engaged in the manufacture of textiles, plastics, rubber goods, and agricultural chemicals. As in the similar central plant for the petrochemical complex at Borger, Texas, the individual plants pretreat their wastes to remove gross amounts of oil, suspended solids, and toxic compounds. The central treatment plant essentially provides secondary treatment, i.e., activated sludge bio-oxidation, preceded by any required physical or chemical treatment (56).

In Houston, Texas the Gulf Coast Waste Disposal Authority was created to process wastes from five petrochemical plants. Various waste streams neutralize each other; one company, for example, eliminated a \$100,000 annual expense for ammonia previously used for neutralization. Here again, however, the participating plants have very similar wastewaters and treatment is largely via bio-oxidation (55).

The Genossenschaften, cooperative associations, in Germany are most often referred to as the outstanding examples of comprehensive regional systems of water resources management. There are thousands of water Genossenschaften in Germany which were organized for special purposes such as drainage control and flood protection. The eight large Genossenschaften of the highly industrialized Ruhr area are the best known and are what are generally referred to as the Genossenschaften by non-Germans. These organizations have almost complete authority over water quantity and quality in their areas. Membership is compulsory and consists of the municipal and rural administrative districts, the coal mines, and the industrial enterprises in each area. Voting power is proportional to the expenses of operation attributable to each member. Costs are assessed by rather elaborate systems designed to reflect expenses incurred and benefits received. Aside from the interestingly unique organization and administrative procedures, the actual treatment facilities are, in effect, joint industrial-municipal plants similar to those in the United States (58) (59).

One must inevitably look to Europe for practical operating experiences with truly regional industrial waste treatment facilities serving a variety of industries. Such facilities are planned and/or operating in France, Sweden, Switzerland, Germany, Italy, and Great Britain. Some of these are cooperatives; others are operated by companies formed to perform such services at a profit. Organizationally, these operations are similar, respectively, to the United States petroleum/petrochemical cooperatives and to the United States contract waste haulers. European facilities, however, mostly treat concentrated solutions and sludges (55).

In France, SERATRADI, a subsidiary of Pechiney-Ugine Kuhlmann, has built a treatment center to serve 100 companies in the Lyon area. The users contributed \$400,000 toward the

\$3 million center, with the government paying the remainder. That center and two smaller centers will treat 54,422 metric tons (60,000 tons) per year with an investment totaling \$5.6 million. FEC Engineering built a \$3 million plant at Hombourg to treat 30,000 kkg (33,000 tons) per year and expects an eight-year payoff from user fees. Ten similar joint industry-government centers are planned in France.

In Great Britain, British Electric Traction Company set up Re-Chem International, Ltd. to treat industrial wastes for a fee. Three \$1.8 million treatment plants have been built. At the Pantypool plant in Wales, nickel, cadmium, and cobalt are being recovered for sale.

In the Mittlefranken district of West Germany, a joint treatment plant operated by the Mittlefranken Special Garbage Disposal Installations Association at Schwabach handles about 100 truckloads of waste per day. Similar installations are planned in three German states. The Schwabach plant recovers and sells oily compounds for road paving and plans to recover copper and chromium when economically attractive.

In Sweden, pharmaceutical manufacturers built a plant to incinerate old medicines and packaging with a subsidy from the National Conservation Board. The plant owners accept the waste from other companies for a fee. In Italy, a joint treatment facility near Milan failed for want of government financial help and three similar projects are in the same sort of trouble with failure likely.

The Daester-Fairtee AG treatment facilities at Zofingen and Turgi in Switzerland provide examples of operating plants more similar to the RWT facility contemplated for the Monongahela River industries. "Semi-concentrated and concentrated" waste solutions are accepted for treatment from 8 cantons (countries) representing one-half of the area of Switzerland and from neighboring countries. The Zofingen plant treats 9,070 kkg (10,000 tons) annually and the Turgi plant treats 27,000 kkg (30,000 tons) annually. The centers are run as private businesses. Performance agreements, based on financial participation, obligate Fairtee AG to accept and treat wastes from within the participating cantons. Charges are fixed by a board which includes company representatives and representatives from the cantons and the Confederate (National) Departments of Environmental Protection and Health (54).

The Swiss plants receive waste solutions in containers or in a semitrailer tank truck of 13.6 kkg (15 tons) capacity. The wastes are segregated into 11 categories as follow: acid-alkaline, metals, no metals, chrome, no chrome, copper, metal hydroxide sludges, cyanide ion solutions, and special solutions. Treatment consists of chrome reduction, neutralization, cyanide

ion destruction, mechanical-biological treatment, and filtration. Unique processing techniques and/or equipment are said to include re-precipitation with proprietary chemicals to overcome the sequestering effects of mixed wastes, the Cyan-Cat process for the catalytic oxidation of cyanide ions, and a screen belt press filter which combines consecutively the actions of a rotary drum filter and a filter press. A unique service provided is the regeneration of ion exchangers on a fee basis for operators of electroplating plants. Final sludge disposal is by landfill.

There are no presently operating regional treatment facilities which provide a model for the contemplated Monongahela regional facility. The above-cited facilities do, however, provide guidance as to the various elements of a potential Monongahela facility, i.e., organization, operation, collection means, treatment alternatives, by-product recovery possibilities, and site-specific potentials. The organizational/ownership/institutional aspects are considered in other sections of this report; here the emphasis will be on the treatment facilities per se.

It should also be realized that a centralized or "terminal" wastewater treatment system in a large steel mill or petroleum refinery is very similar to the regional facility being considered here. Such a treatment plant collects wastewaters from many different types of operations via quite large sewer systems; wastewaters are often minimized by water recirculation and reuse at the points of use, and strong solutions are often treated or pretreated in separate facilities or hauled away by outside contractors. The single-plant terminal facility and the regional facility thus differ only in flow volumes, distances from source to treatment plant, and diversity of wastewater types. Even so, the differences are not as great as might be expected. A large plant may produce 378,500 cu m/day (100 mgd) or more of wastewater, cover hundreds of hectares containing kilometers of sewer lines, and aggregate wastes of a dozen or more different types.

The Fairless Works of United States Steel Corporation provides the best example of a terminal treatment plant at an integrated steel mill. About 284,000 cu m/day (75 mgd) of wastewater from 13 manufacturing processes are treated here.

Approximately 284,000 cu m/day (75 mgd) enters the waste-treatment system as individual wastes through more than 40 separate outflows after collecting more than a dozen different chemical compositions and physical types of wastes. These wastes comprise solutions of acids, alkalies, and soluble oils; emulsions of insoluble oils; and suspensions of mill scale and flue dust. Sedimentation, flocculation, clarification, skimming, and neutralization processes are utilized as required to treat specific wastes. For convenience in processing, separate treatment plants handle the special wastes at the sheet and tin mill, and at the blast furnaces.

In the waste-treatment plant of the sheet and tin mills, insoluble oil wastes consisting primarily of various oils in the effluent from the skimmer tanks of the five-stand mill, plus small quantities of oily wastewater from the dirty-water sumps, flow to a primary receiver and oil-removal tank. Soluble-oil wastes discharged from the sumps or tanks of the roll shop, the electrostatic precipitators, the oil-skimmer tanks and rolling-solution tanks of the four-stand mill and the rolling-solution tanks of the Ferrolite reduction mill also flow to the primary receiver and oil-removal tank. The floating oils are removed by skimming and are pumped to a 160,000 liter (42,300 gal.) storage tank. These oils are disposed of in an incinerator-type furnace or trucked away for disposal. The sludge is removed by a drag-out conveyor discharging into a container that is occasionally emptied on a refuse dump for disposal. The oily waste effluent, with the insoluble oils removed and the soluble oils remaining in solution, flows to a flash mixer.

Synthetic palm oil, sperm oil, various lubricating oils, hydraulic oils, rolling-solution oil, paraffin, greases, and soluble oils are present in the recovered oil. The bulk of the oil is received in the insoluble states. The recovered oil amounts to about 208,000 liters (55,000 gallons) per month.

Oils from the five-stand mill usually arrive at the primary receiving tank in a heavy, viscous state having approximately the specific gravity of water and tend to "hang" in the water rather than float. The flow of these oils is semicontinuous, with periodic dumps of several hundred liters. Of all the oils received, those from the five-stand mill are the most difficult to handle. The lubricating oils, hydraulic oils, and rolling-solution oil used on the four-stand mill remain in a fairly fluid state and will float to the surface, and can be removed by skimming.

Acid rinse water from the 142 centimeter (56 inch) and 207 centimeter (80 inch) continuous pickling lines, from the two electrolytic-tinning lines, and the Ferrolite cleaning line, is pumped to two storage tanks where it is stored and then pumped to the clarifiers or to the emergency acid-neutralization tanks. Acid wastes (waste-pickle liquor and chromic-acid wastes) from the tube-producing section also enter this system at the storage tanks.

Sufficient acid rinse water is fed to the flash mixer to mix with the effluent from the primary receiver to control the pH at about 3 and crack the soluble-oil emulsions. The balance of the acid rinse water is pumped to the acid-neutralization tanks, where it is neutralized with lime and the resulting sludge is pumped to a sludge lagoon.

The flash mixer discharges through controlling devices to two clarifiers, where alkaline wastes and lime slurry are added.

Flocculation in the clarifiers, followed by detention in the sedimentation chambers with controlled flows, allows each clarifier to operate up to rated capacity for neutralization of large quantities of acid rinse water. Oil is skimmed from the clarifier surface and pumped to storage. Sludge is pumped to the sludge lagoon. The clarifier effluents combine and flow to an oil separator for further removal of oil.

Waste pickle liquor from the two electrolytic-tinning lines, totaling about 378,500 liters (100,000 gallons) per day, is pumped to storage in two 757,000 liter (200,000 gallons) tanks located at the oil-interception plant site. Waste pickle liquor not required for the waste-treatment processes is trucked to an independent concern that produces paint pigments. Normally, the waste pickle liquor is removed continuously, leaving the tanks partly empty to provide temporary storage in the event of an interruption in trucking operations. Sufficient lime-handling and slaking facilities are provided to neutralize the entire pickle-liquor output in either one or both of two neutralization plants if, for any reason, neutralization becomes necessary.

Alkaline wastes, consisting primarily of cleaning solutions containing sodium orthosilicate, are effectively employed in the treatment process to raise the pH of the acid and soluble-oil wastes for sludging purposes. The contents of the cleaning-solution tanks of the tinning lines, the continuous-annealing lines and the continuous-cleaning line are pumped to storage and fed by controlled flow to the clarifiers. Slaked lime is added as slurry in sufficient quantities to raise the pH in the clarifiers to about 10 and precipitate the metals from solution. The floc formed in this process is of value in clarifying the effluent and removing some of the oils from the precipitated sludge.

Chromic-acid dump and rinse solutions from the tinning lines are mixed with the sulphuric acid wastes from these lines and pumped to two 284,000 liters (75,000 gallons) acid rinse-water storage tanks at the oil-interception plant. Any pre-treatment with acid, therefore, takes place in the acid rinse-water storage tanks. The ferrous sulphate content of the acid rinse waters is sufficient to reduce the sodium dichromate to trivalent chromium sulphate. Detention time in the storage tanks is more than sufficient to allow the reaction to go to completion. From the storage tanks, the chromic-acid wastes are pumped with the acid rinse waters to the flash mixer and pass into the clarifiers, where the addition of lime precipitates the chromium as chromic hydroxide. The sodium acid phosphate is converted to ferrous phosphate and deposited in the clarifiers with the chromic hydroxide. The sodium sulphate formed by the reactions is not removed. The sludge is pumped to the sludge lagoon.

Wastes of the coke plant, with the exception of the ammonia-still waste, are segregated in a separate circulatory system,

closed within itself. The ammonia-still waste, containing about 10 milligrams per liter (mg/l) of phenols, is pumped from the lime-settling basin to the terminal waste-treatment plant where it is disposed of by oxidation and dilution before entering the river. The other wastes are used for coke quenching and never enter the river.

Flue-dust-laden waters from the gas washers and electrostatic precipitators pass through a conventional primary thickener and then to a secondary clarification plant in the blast-furnace area where effluent from the primary thickener is mixed with lime slurry in a flash mixer and flows to a flocculator chamber.

Sludge from the secondary clarifier is pumped, along with primary-thickener sludge, to a separate flue-dust storage lagoon. Clarifier effluent flows directly to the river through a measuring flume.

The effluent from the scale flumes of the bar mill, the 203-centimeter (80 inch) hot-strip mill, the billet mill, the slab mill, and the blooming mill flows through scale pits, where solids settle out, from which the clarified water goes to the terminal treatment plant. Scale pits of the skelp and weld mill of the tube-producing section are tied into this system.

Most of the cooling water used in the power house is pumped to the service water system. The remainder of this water joins power-house boiler blowdown and cooling water from the blast furnaces, open-hearth furnaces, and coke plant, and is discharged into the river. Backwash from the boiler-water treatment system, boiler blowdown from the open-hearth shop, and washdown water from the ladle shop go to the terminal treatment plant.

The BPCTCA model system given in the Development Document for Effluent Limitations for the Petroleum Refining Industry is probably the best example of a terminal treatment facility for petroleum refinery wastewaters, i.e., a type of wastewater amenable to bio-oxidation. This model system is shown in Figure 1 (67).

End-of-pipe control technology in the petroleum refining industry relies heavily upon the use of biological treatment methods. These are supplemented by appropriate pretreatment to insure proper conditions in the feed to the biological system. When used, initial treatment most often consists of neutralization for control of pH or equalization basins to minimize shock loads on the biological systems. The incorporation of solids removal ahead of biological treatment is not as important as it is in treating municipal wastewaters.

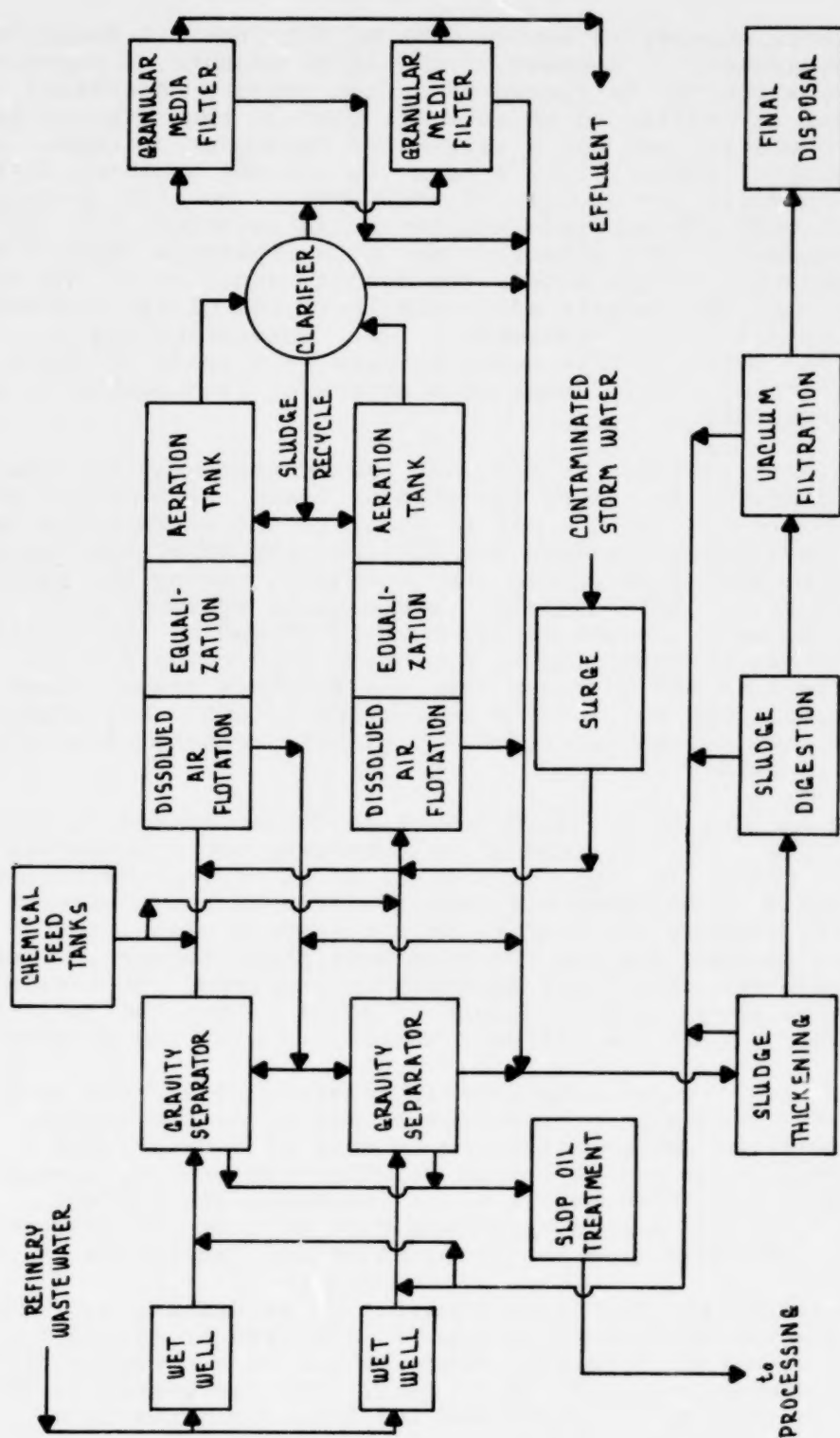


Figure 1. BPCTCA wastewater treatment system for petroleum refining.

Gravity separators remove most of the free oil found in refinery wastewaters. Because of the large amounts of reprocess-able oils which can be recovered in the gravity separators, these units must be considered an integral part of the refinery processing operation and not a wastewater treatment process. The functioning of gravity-type separators depends upon the difference in specific gravity of oil and water. The gravity-type separator will not separate substances in solution, nor will it break emulsions. The effectiveness of a separator depends upon the temperature of the water, the density and size of the oil globules, and the amounts and characteristics of the suspended matter present in the wastewater. The "susceptibility to separation" (STS) test is normally used as a guide to determine what portion of the influent to a separator is amenable to gravity separation.

The API separator is the most widely used gravity separator. The basic design is a long rectangular basin, with enough detention time for most of the oil to float to the surface and be removed. Most API separators are divided into more than one bay to maintain laminar flow within the separator, making the separator more effective. API separators are usually equipped with scrapers to move the oil to the downstream end of the separator where the oil is collected in a slotted pipe or on a drum. On their return to the upstream end, the scrapers travel along the bottom moving the solids to a collection trough. Any sludge which settles can be dewatered and either incinerated or disposed of on a landfill.

The purpose of equalization is to dampen surges in flows and loadings. This is especially necessary for a biological treatment plant, as high concentrations of certain materials will upset or completely kill the bacteria in the treatment plant. By evening the loading on a treatment plant, the equalization step enables the treatment plant to operate more effectively and with fewer maintenance problems. When equalization is not present, an accident or spill within the refinery can greatly affect the effluent quality or kill the biomass.

The equalization step usually consists of a large pond that may contain mixers to provide better mixing of the wastes. In some refineries the equalization is done in a tank. The equalization step can be before or after the gravity separator, but is more effective before as it increases the overall efficiency of the separator. Care must be taken to prevent anaerobic decomposition in the equalization facilities.

Dissolved air flotation consists of saturating a portion of the wastewater feed, or a portion of the feed or recycled effluent from the flotation unit with air at a pressure of 3.722 to 5.083 atmosphere. (40 to 60 psi). The wastewater or effluent recycle is held at this pressure for 1 to 5 minutes in a

retention tank and then released at atmospheric pressure to the flotation chamber. The sudden reduction in pressure results in the release of microscopic air bubbles which attach themselves to oil and suspended particles in the wastewater in the flotation chamber. This results in agglomerates which, due to the entrained air, have greatly increased vertical rise rates of about 0.152 to 0.305 meters/minute (0.5 to 1.0 feet/minute). The floated materials rise to the surface to form a froth layer. Specially designed flight scrapers or other skimming devices continuously remove the froth. The retention time in the flotation chambers is usually about 10 to 30 minutes. The effectiveness of dissolved air flotation depends upon the attachment of bubbles to the suspended oil and other particles which are to be removed from the waste stream. The attraction between the air bubble and particle is a result of the particles surface and bubble-size distribution.

Chemical flocculating agents, such as salts of iron and aluminum, with or without organic polyelectrolytes, are often helpful in improving the effectiveness of the air flotation process and in obtaining a high degree of clarification.

Dissolved air flotation is used by a number of refineries to treat the effluent from the oil separator. Dissolved air flotation using flocculating agents is also used to treat emulsions. The froth skimmed from the flotation tank can be combined with other sludges (such as those from a gravity separator) for disposal. The clarified effluent from a flotation unit generally receives further treatment in a biological unit, prior to discharge. In two refineries, dissolved air flotation is used for clarification of biologically treated effluents.

Activated sludge is an aerobic biological treatment process in which high concentrations (1500-3000 mg/l) of newly-grown and recycled microorganisms are suspended uniformly throughout a holding tank to which raw wastewaters are added. Oxygen is introduced by mechanical aerators, diffused air systems, or other means. The organic materials in the waste are removed from the aqueous phase by the microbiological growths and stabilized by biochemical synthesis and oxidation reactions. The basic activated sludge process consists of an aeration tank followed by a sedimentation tank. The flocculant microbial growths removed in the sedimentation tank are recycled to the aeration tank to maintain a high concentration of active microorganisms. Although the microorganisms remove almost all of the organic matter from the waste being treated, much of the converted organic matter remains in the system in the form of microbial cells. These cells have a relatively high rate of oxygen demand and must be removed from the treated wastewater before discharge. Thus, final sedimentation and recirculation of biological solids are important elements in an activated sludge system.

Sludge is wasted on a continuous basis at a relatively low rate to prevent build-up of excess activated sludge in the aeration tank. Shock organic loads usually result in an overloaded system and poor sludge settling characteristics. Effective performance requires pretreatment to remove or substantially reduce oil, sulfide ions and phenol. The pretreatment units most frequently used are: gravity separators and air flotation units to remove oil; and sour water strippers to remove sulfides, mercaptans, and phenol. Equalization also appears necessary to prevent shock loadings from upsetting the aeration basin. Because of the high rate and degree of organic stabilization possible with activated sludge, application of this process to the treatment of refinery wastewaters has been increasing rapidly in recent years.

Many variations of the activated sludge process are currently in use. Examples include: the tapered aeration process, which has greater air addition at the influent where the oxygen demand is the highest; step aeration, which introduces the influent wastewater along the length of the aeration tank; and contact stabilization, in which the return sludge to the aeration tank is aerated for 1 to 5 hours. The contact stabilization process is useful where the oxygen demand is in the suspended or colloidal form. The completely mixed activated sludge plant uses large mechanical mixers to mix the influent with the contents of the aeration basin, decreasing the possibility of upsets due to shock loadings. The Pasveer ditch is a variation of the completely mixed activated sludge process that is widely used in Europe. Here brushes are used to provide aeration and mixing in a narrow oval ditch. The advantage of this process is that the concentration of the biota is higher than the conventional activated sludge process, and the waste sludge is easy to dewater. There is at least one refinery using the Pasveer ditch type system.

The activated sludge process has several disadvantages. Due to the amount of mechanical equipment involved, its operating and maintenance costs are higher than other biological systems. The small volume of the aeration basin makes the process more subject to upsets than either oxidation basins or trickling filters.

The activated sludge process is capable of achieving very low concentrations of BOD, COD, total suspended solids (TSS) and oil, dependent upon the influent waste loading and the particular design basis. Reported efficiencies of BOD removal are in the range of 80 to 99%.

There are several types of granular media filters: sand, dual media, and multimedia. These filters operate in basically the same way, the only difference being the filter media. The

sand filter uses a relatively uniform grade of sand resting on a coarser material. The dual media filter has a coarse layer of coal above a fine layer of sand. Both types of filters have the problem of keeping the fine particles on the bottom. This problem is solved by using a third very heavy, very fine material, (usually garnet) beneath the coal and sand.

As the water passes down through a filter, the suspended matter is caught in the pores. When the pressure drop through the filter becomes excessive, the flow through the filter is reversed for removal of the collected solids. The backwash cycle occurs approximately once a day, depending on the loading, and usually lasts for 5 to 8 minutes. Most uses of sand filters have been for removing oil and solids prior to an activated carbon unit. There is one refinery that uses a mixed media filter on the effluent from a biological system. Granular media filters are shown to be capable of consistent operation with extremely low TSS and oil effluent discharges, on the order of 5 to 10 mg/l.

The terminal treatment facilities described for steel mill and petroleum refinery wastewaters will produce effluent qualities approximately as contemplated for BPCTCA. The proposed Monongahela River regional facility would need to produce an effluent quality equal to BATEA limitations for the aggregate of the industrial plants served.

The BATEA model system for petroleum refining is shown in Figure 2. The added treatment beyond BPCTCA is activated carbon adsorption. The adsorption is a function of the molecular size and polarity of the absorbed substance. Activated carbon preferentially adsorbs large organic molecules that are non-polar.

An activated carbon unit follows a solids removal process, usually a sand filter which prevents plugging of the carbon pores. From the filter the water flows to a bank of carbon columns arranged in series or parallel. As the water flows through the columns the pollutants are adsorbed by the carbon, gradually filling the pores. At intervals, portions of the carbon are removed to a furnace where the adsorbed substances are burned off. The regenerated carbon is reused in the columns, with some makeup added, because of handling and efficiency losses.

Activated carbon processes currently have only limited usage in the refining industry. However, there are new installations in the construction planning stages. The increasing use of activated carbon has occurred because activated carbon can remove organic materials on an economically competitive basis with biological treatment. Activated carbon regeneration furnaces have high energy requirements.

The BATEA model systems for steel mill wastewaters as given in the Development Documents (Phases I and II) for Effluent Limitations in the Steel Industry generally incorporate pressure sand filters as a final step and are thus similar to the BPCTCA petroleum refining model. Coke plant and blast furnace effluents contain ammonia, phenol, and cyanides which can be removed by alkaline chlorination plus carbon adsorption as shown in Figure 3, taken from the development document BATEA model for blast furnaces; the treatment scheme for coke plants is similar. An alternative BATEA treatment model for coke plants is shown in Figure 4; the alternative treatment uses multi-stage biological treatment (52).

The treatment models described above cover the means required to treat most expected classes of wastewater component materials, with the exception of chemical reduction required, e.g., to reduce soluble hexavalent chromium to precipitable trivalent chromium. It is most likely that all chromium will be present as the trivalent form due to the large excesses of ferrous iron as from spent pickling solutions.

Metal-containing acidic solutions, such as spent pickling solutions, may be treated by neutralization, neutralization with air oxidation, and by acid regeneration. Most steel mills dispose of pickle liquor by contract hauling or deepwell disposal. The latter, of course, is zero discharge if the possible adverse effects are not considered, such as groundwater contamination, etc. Contract hauling usually involves lime neutralization and offsite disposal in abandoned strip mines or quarries. Neutralization with lime typically produces an effluent with 4 mg/l or less of total iron, calcium salts of the acids used, and suspended solids dependent upon the clarification method used. A bulky, never-drying sludge results. Neutralization with air oxidation produces a somewhat better effluent quality, and also a sludge which compacts and dries when dumped. Regeneration of hydrochloric or sulfuric acid results in zero discharge of strong liquors; the rinsewaters remain to be treated by neutralization. In many mills, rinsewaters are combined with other wastewater and are neutralized as part of a terminal treatment system, providing at least part of the iron salts used as flocculants for improved removal of suspended solids and oil (68).

The metals can be precipitated by lime neutralization and separated by sedimentation-flocculation. The effluent concentrations of dissolved metals are generally less than 1.0 mg/l for each metal. Proper pH control and efficient sedimentation are necessary to consistently achieve low effluent concentrations, and polyelectrolytes are usually used to promote sedimentation.

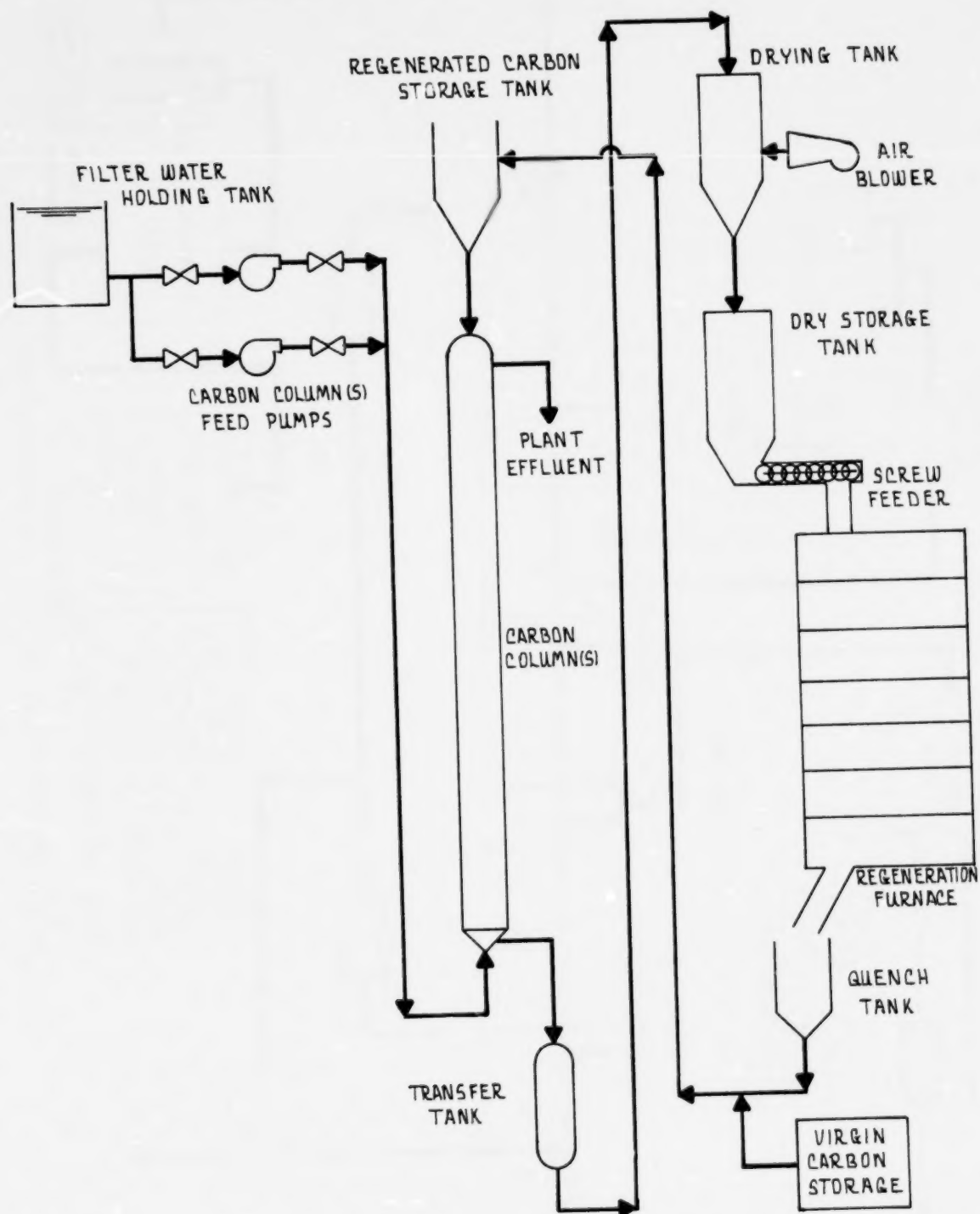


Figure 2. Proposed treatment for petroleum refining.

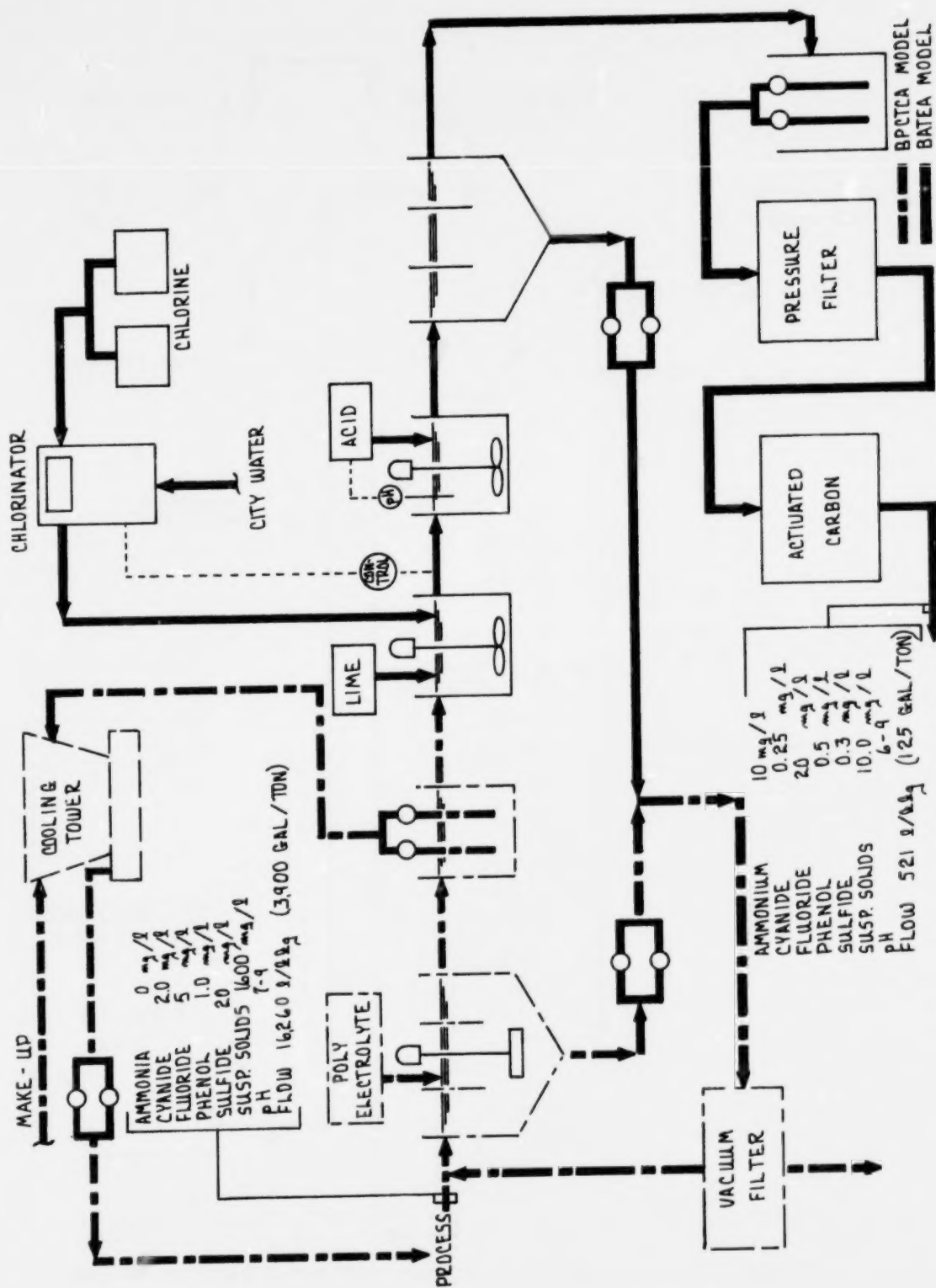


Figure 3. BPCTCA blast furnace treatment model.

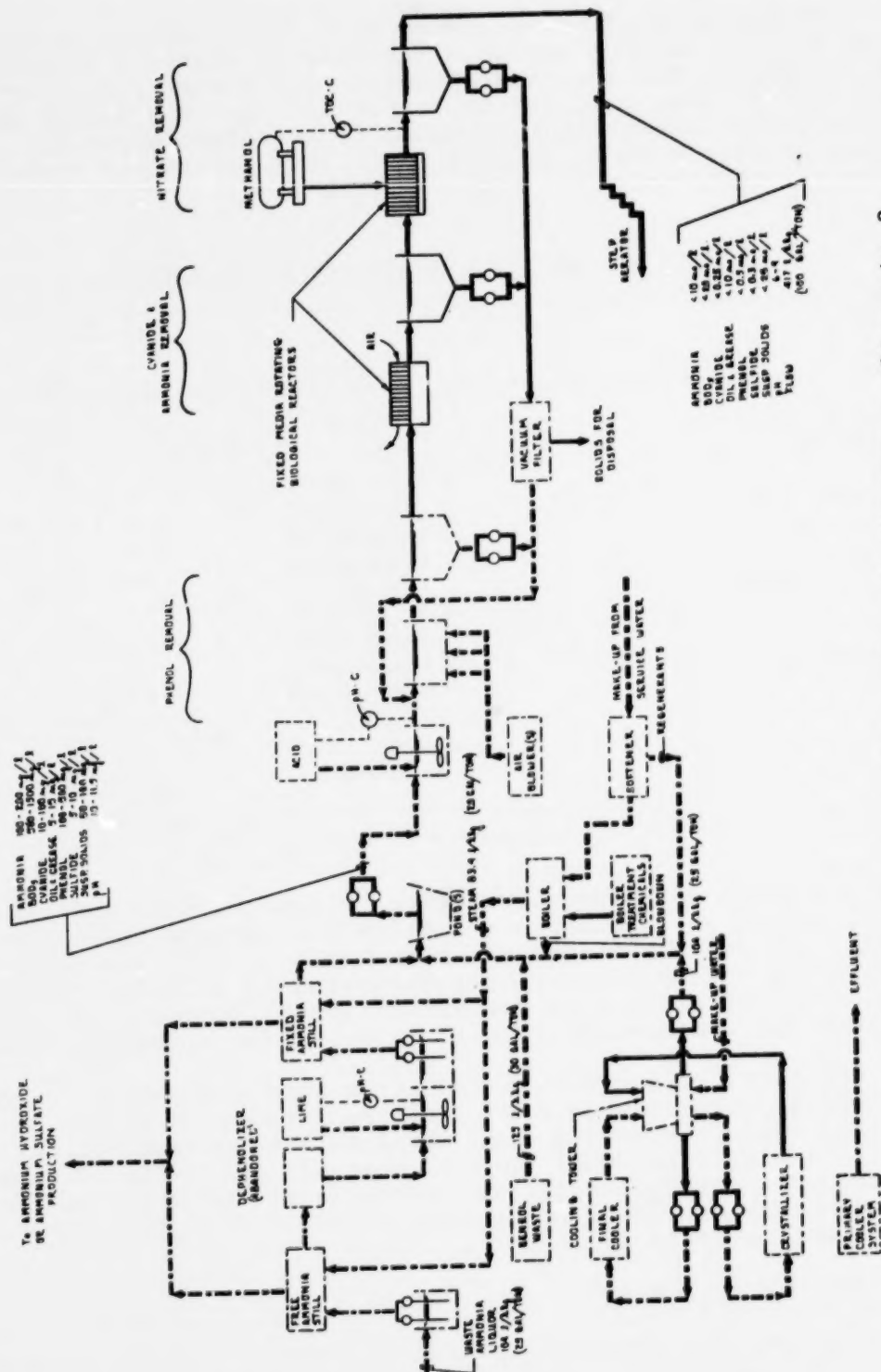


Figure 4. BATEA by-product coke subcategory - alternate 2.

Optimum precipitation of the metal ions depends primarily on pH and the valence states. The valence state is of particular importance for iron and chromium; the former precipitating more readily when oxidized to ferric iron and the latter precipitating most readily when reduced to trivalent chromium. The optimum pH levels for precipitation of the metals are shown in Table 11, based upon the work of Smith (69).

TABLE 11. pH LEVELS FOR OPTIMUM PRECIPITATION

	pH	mg/l
Aluminum	8.0	0.1
Molybdenum	5.0	0.5
Lead	6.5 and above	0
Vanadium	5.0-8.0	0
Titanium	6.5 and above	0
Cobalt	11.0 and above	0
Chromium (Total)	8.0	0.15
Copper	9.5 and above	0
Iron	8.0 and above	0.2
Manganese	9.5 and above	0.1
Nickel	9.5 and above	0.1
Zinc	9.5-11	0
Cadmium	8.0 and above	0.05
Tin	3.0-6.5	0.9

Aluminum, molybdenum, vanadium, chromium, tin, and zinc are significantly soluble above and below the optimum pH levels shown. The concentrations shown in Table 11 are from laboratory experiments and should not be interpreted as defining concentration levels attainable in commercial installations. The concentrations are comparatively valid as among the different ions.

Solutions of the metals in nitric acid are unique in that the metals, particularly iron, will be largely or wholly in the oxidized state, depending upon the free acid concentration. The principal significance of this is that air oxidation is generally not needed to produce a ferric hydroxide sludge after neutralization of stainless (HNO₃-HF) pickle liquor. The oxidation-reduction reaction is as follows:



Cyanides are oxidized at high pH levels, usually by chlorine, i.e., alkaline chlorination. The initial reaction is very

fast, producing cyanates. Maintenance of a chlorine residual at near neutral pH for an hour or more oxidizes the cyanate ion to nitrogen and CO₂. Essentially zero cyanide ion levels can be achieved. Cyanide can also be oxidized electrolytically, and cyanogen compounds can be treated biologically.

Hexavalent chromium is reduced at a low pH by sulfur dioxide, ferrous sulfate, sodium metabisulfite, or sodium hydro-sulfite to trivalent chromium. The pH is then raised with an alkaline reagent, precipitating the reduced chromium as the hydroxide. Proper operation and efficient sedimentation can reduce hexavalent chromium to nearly zero.

Although a single model is not available upon which to base the Monongahela River regional industrial facility, the above-cited facilities and/or systems provide a good basis in the aggregate from which to build an initial treatment facility model for the purposes of this study.

The most likely treatment scheme appears to be a combination of the petroleum industry and the steel industry document models, plus the terminal treatment-type facility at Fairless Works, United States Steel Corporation. All factors considered, it is most likely that the unit operations in these individual treatment models, combined into one, would provide the range of treatment required. It is beyond the scope of the present study to examine in detail the treatability of each wastewater constituent, nor is such an effort really justified. The conclusions of the EPA study entitled, "Combined Steel Mill and Municipal Wastewaters Treatment," (7) indicated that a variety of steel mill wastewaters can be treated in combination with domestic sewage with 50% to 80% reductions in organic carbon as measured by total organic carbon (TOC). A 15-day bench-scale unit, for example, used the following influent wastewater blend with better than 75% reduction in TOC.

Coke Plant Wastewaters	38.3%
Palm Oil Recovery Effluent	50.0%
Tin Mill and Galvanizing Wastewaters	11.2%
Pickling Line Scrubber Effluent	0.5%

The bench-scale plant influent contained

Phenol	32.5 mg/l
Cyanide	3.8 mg/l
Oil and Grease	2.1 mg/l
Ammonia	18.5 mg/l
TOC	103 mg/l

Complete metals analyses were not made. However, the hexavalent chromium in the tin mill wastewater (30.7 mg/l), the tin

in the detinning plant effluent (138 mg/l), and the iron in the scrubber effluent (760 mg/l) account for at least the following concentrations:

Hexavalent Chromium	1.1 mg/l
Tin	4.8 mg/l
Iron	3.8 mg/l

The report concluded that the tin mill wastewaters did not inhibit the biological process significantly, that wide variations in influent waste strengths could be tolerated (79-230 mg/l TOC with +70% reductions), and that 90% reductions would be achievable with retention times greater than used in these tests (max. = 16.6 hours). The primary sources of the required organic food load was domestic sewage and the palm oil used in cold rolling operations. The BOD/COD ratio in the coke plant wastewaters averaged 0.505 and TOC averaged 65.6% of the BOD.

In Table 12 the permissible limits of various materials in sewage plant influents are given from a 1960 survey of plants in Germany:

TABLE 12. Permissible Limits For Sewage Plant Influent

	Trickling filter	Activated sludge	Sludge digestion
Cyanide, mg/l	1-2	1-1.6	25
Lead, mg/l	5	-	-
Cadmium, mg/l	-	1-5	-
Chromium, mg/l	10	2-5	200
Iron, mg/l	35	-	-
Copper, mg/l	1	1	100
Nickel, mg/l	-	6	200-500
Phenol, mg/l	50	250	-
Zinc, mg/l	-	1-3	-
Thiocyanate, mg/l	-	-	180
Sulfide, mg/l	-	-	70-200
Xylene, mg/l	-	-	870

The Genossenschaften methods of assessing service charges on those who discharge other than domestic sewage to the treatment plants are based upon "non-settleable" solids content, BOD concentrations, a modified COD test, and a fish toxicity test. The first three factors are evaluated as the ratio of "actual" to "allowable" concentrations and the toxicity is expressed as the dilution ratio necessary to reach non-toxic concentrations. The final result is thus, essentially, a measure of treatability

a waste based upon the degree of treatment needed to produce the required effluent quality; the required quality is that which will support fish in the receiving stream. The actual effect is thus to limit toxic materials much below the "critical" levels imposed by the effects on the treatment plant processes.

The federal guidelines for "Pretreatment of Pollutants Introduced Into Publicly Owned Treatment Works" (71) gives the concentrations of pollutants which inhibit biological treatment processes as shown in Table 13.

TABLE 13. POLLUTANT CONCENTRATIONS WHICH INHIBIT BIOLOGICAL TREATMENT

Constituent	Aerobic Processes	Anaerobic Processes	Nitrification
Copper, mg/l	1.0	1.0	0.5
Zinc, mg/l	5.0	5.0	0.5
Hexavalent Chromium, mg/l	2.0	5.0	2.0
Total Chromium, mg/l	5.0	5.0	-
Nickel, mg/l	1.0	2.0	0.5
Lead, mg/l	0.1	-	0.5
Cadmium, mg/l	-	0.02 (1)	-
Silver, mg/l	0.03	-	-
Vanadium, mg/l	10	-	-
Sulfide, mg/l	-	100 (1)	-
Ammonia, mg/l	-	1500	-
Cyanide, mg/l	-	1.0	2.0
Oil, mg/l	50	50	50
Benzene, mg/l	-	50 (1)	50

(1) Digester influent.

Concentrations limits have been given as in Table 14 for sewage plant effluents, stream quality for recreational uses, and for drinking water.

TABLE 14. POLLUTANT CONCENTRATIONS FOR VARIOUS WATER USES

	<u>Los Angeles (1)</u>	<u>Missouri (2)</u>	<u>Drinking water (3)</u>
Mercury, mg/l	-	-	0.002
Boron, mg/l	2.0	0	-
Lead, mg/l	0.1	0.1	0.05
Fluoride, mg/l	1.5	1.5	1.6-3.4
Arsenic, mg/l	0.05	-	0.05
Hexavalent Chromium, mg/l	10.05	-	0.05
Copper, mg/l	3.0	0.2	1.0
Iron, plus Manganese, mg/l	0.3	-	0.3
Zinc, mg/l	15	0.01	5.0
Iron, mg/l	-	1.0	-
Total Chromium, mg/l	-	1.0	0.05
Cyanide, mg/l	-	0.02	0.0.-0.02
Cadmium, mg/l	-	0.2	0.01
Nickel, mg/l	-	0.8	-
Barium, mg/l	-	0	1.0

(1) Whittier Narrows Reclamation Plant Effluent, used for land spread recharge.

(2) State of Missouri, Zone 1, Blue River, recreational stream.

(3) United States Environmental Protection Agency, 1975 or U.S.P.H.S., 1962 (maximum permissible or recommended).

Comparison of the concentrations of the various pollutants which reportedly interfere with biological treatment processes with the concentrations in the proposed treatment plant influent indicates that no toxic concentrations are expected, i.e., biological treatment is entirely feasible from that standpoint. Comparisons of the concentrations given for various critical water uses indicates that the treatment plant effluent would be directly usable for most purposes, and certainly suitable for discharge to surface waters.

SECTION 7

INTERCEPTOR SEWER SYSTEM

The most obvious method of collecting and transporting the industrial effluents to be treated is an interceptor sewer which would generally follow the course of the Monongahela River. The surface relief in the areas is 91.4 to 182.9 meters (300 to 600 feet) and the terrain is exceedingly rough, consisting mainly of steep hillsides and narrow valleys. The straight-line distance from Allenport to the "point" at Pittsburgh is 43.4 kilometers (27 miles); whereas the river is 75.6 kilometers (47 miles) long with an elevation difference of 12.2 meters. The required 79.6 meters (261 feet) of head for a gravity system seems clearly preferable to any contemplated system involving tunneling and lift stations to follow a straight-line course. Additionally, the right-of-way acquisition costs would be minimized using the river route.

Several alternative interceptor designs were evaluated at varying capacities and flow velocities. It readily became apparent that flow velocities of 61 to 122 centimeters per second (cm/sec). (2 to 4 feet/second (fps) would be the optimum from a cost standpoint. The ALCOSAN system used 76.2 cm/sec. (2.5 fps) as a design criterion, tending to confirm this conclusion. The cost analysis was based upon a total capacity of 503,500 cu m/day (133 mgd) and upon data developed by the Southwest Pennsylvania Regional Planning Commission specifically applicable to western Pennsylvania terrain and construction conditions. The costs there from are in 1969 dollars and for minimum and maximum costs, i.e., a range rather than an average. The design data are shown in Table 15. Four lift stations would be required. Cost estimates for pipe and installation on this basis are shown in Table 16. The costs of pumps, lift stations, valves controls, manholes, etc. add 50% to the above costs.

In 1977 dollars, the costs would be further increased by the ration of the 1977/1969 Engineering News Record Construction Cost Indexes, i.e., by the ratio of 2600/1285, or 2.02. The interceptor total costs would be:

$$\text{Minimum} = \$20,243, 428 \times 1.50 \times 2.02 = \$ 61,339,000$$

$$\text{Maximum} = \$36,862, 421 \times 1.50 \times 2.02 = \$111,693,000$$

TABLE 15. INTERCEPTOR SEWER DESIGN DATA

Kilometer point	Distance kilometers	CUM total flow cu m/day	Unit sewer length, meters	Slope m/100m	Line Size, cm	Velocity m/sec	% Slope loss, meters	Unit head
75.6-70.3	5.3	12187	5311	2.49	45.72	0.85	.25%	13.27
70.3-69.2	1.1	13210	1127	2.49	45.72	0.85	.25%	2.82
69.2-57.6	11.6	32930	11587	0.89	81.28	0.70	.09%	10.42
57.6-49.4	8.2	32930	8208	0.89	81.28	0.70	.09%	7.39
49.4-48.9	0.5	32930	483	0.89	81.28	0.70	.09%	0.43
48.9-47.5	1.5	33043	1448	0.89	81.28	0.70	.09%	1.28
47.5-37.7	9.8	33081	11036	0.89	81.28	0.70	.09%	9.93
37.7-36.5	1.2	33194	1127	0.89	81.28	0.70	.09%	1.01
36.5-32.2	4.3	83649	4345	0.69	121.92	0.82	.09%	3.02
32.2-29.8	2.4	83838	2414	0.69	121.92	0.82	.07%	1.68
29.8-26.4	3.4	84292	3380	0.69	121.92	0.82	.07%	2.37
26.4-26.1	0.3	84368	322	0.69	121.92	0.82	.07%	0.22
26.1-24.9	1.2	84368	1127	0.69	121.92	0.82	.07%	0.79
24.9-24.1	0.8	121763	805	0.69	142.24	0.88	.07%	0.56
24.1-22.2	1.9	171120	1931	0.89	152.40	1.07	.09%	1.74
22.2-19.3	2.9	171271	2897	0.89	152.40	1.07	.09%	2.59
19.3-19.0	0.3	260181	322	0.79	187.96	1.01	.08%	0.26
19.0-16.6	2.4	328311	2414	1.21	187.96	1.28	.12%	2.89
16.6-15.3	1.3	328349	1287	1.21	187.96	1.28	.12%	1.54
15.3-11.9	3.4	377667	3380	1.31	198.12	1.37	.13%	4.39
11.9-8.8	3.0	377667	3058	1.31	198.12	1.37	.13%	3.97
8.8-8.4	0.4	378010	483	0.40	198.12	1.37	.13%	0.62
8.4-7.2	1.2	378046	1127	1.31	198.12	1.37	.13%	1.46
7.2-1.3	5.9	503102	5955	0.69	243.84	1.22	.07%	4.15
1.3-0	1.3	503102	1287	0.69	243.84	1.22	.07%	0.88

TABLE 16. INTERCEPTOR SEWER PIPE AND INSTALLATION COSTS

Total unit lengths, meters	Line size, cm	Estimate line cost per meter per centimeter of diameter		
		minimum	total	maximum
6437	45.72	\$1.5500	\$ 456,164	\$2.3248
33889	81.28	1.6146	4,447,412	3.3583
11587	121.92	1.7438	2,463,443	3.4872
805	142.24	1.9375	221,850	3.6811
4828	152.40	2.3250	1,710,720	3.8750
4023	187.96	2.8417	2,148,788	4.2625
8047	198.12	2.9062	4,633,272	4.3527
7242	243.84	3.2292	5,702,410	4.8435
TOTAL	76858	TOTAL	\$21,784,059	TOTAL
				\$36,849,228

Basis for estimates made:

1. TDH not to exceed 15.24 meters (soft) for any unit length using $C = 100$. (Pipe friction factor)
2. Velocity to be maintained at 61-122 cm/sec. (2-4 ft/sec)
3. Estimates in 1969 dollars. (Taken from "Alternate Sewer System Cost Evaluation", Southwest Pennsylvania Regional Planning Commission, 1969). Costs therein are as follows:

Dia., cm	Minimum		Maximum	
	Cost/cm/meter	Cost per meter	Cost/cm/meter	Cost per meter
25.4	\$ 1.2917	\$ 32.81	\$ 1.9373	\$ 49.21
50.8	1.5500	78.74	2.3248	118.10
76.2	1.6146	123.03	3.3582	255.89
152.4	2.3250	354.33	3.8750	590.55
203.2	2.9062	590.54	4.3526	884.45
254.0	3.2292	820.22	4.8434	1230.22
508.0	3.8750	1968.50	5.8123	2952.65
762.0	4.8437	3690.90	7.7499	5905.42
1016.0	7.1042	7217.87	10.6560	10826.50

The ALCOSAN interceptors totaled 157.7 kilometers (98 miles) and were designed for a maximum flow of 1,600,000 cu m/day (412 mgd) at a velocity of 76.2 cm/sec (2.5 fps). When completed in 1956, the cost was \$90 million (ENR = 690). The cost per kilometer in 1977 dollars (ENR = 2600) would be:

$$\$90 \text{ million} \div 157.7 \text{ kilometers} \times (2600/700) =$$

\$2.12 million per kilometer

(\$3.4 million per mile)

At a flow of 503,405 cu m/day, the RWT interceptor on this basis would cost:

$$\$2.12 \text{ million per kilometer} \times (133/412)^{0.390} =$$

1.36 million per kilometer

\$2.19 million per mile)

using the scale-up factor according to Klemetson and Grenney (73). The comparison between the estimated cost above of \$1.35 million per kilometer (\$2.19 million/mile) with those based upon the Southwestern Pennsylvania Regional Planning Commission (SPRPC) data of \$0.81 to \$1.49 million per kilometer (\$1.3 to \$2.4 million/mile) indicate that the SPRPC-based estimates are valid and that the actual cost would be close to the maximum, i.e., \$111 million in 1977 dollars.

SECTION 8

TREATMENT PLANT DESIGN

Assuming, as has been previously explained, that the RWT facility could discharge not more than the total of the BATEA allowable effluent loads from each of the 68 plants in whatever volume of water is chosen, there are two logical choices. The volume could be the BPCTCA volumes upon which the effluent guidelines were based, i.e., 908,000 cu m/day (240 mgd) as shown in Table 10. The volume could alternatively be 10% of the presently discharged process water and unsegregated non-contact cooling water, i.e., about 466,000 cu m/day (123 mgd).

Since BATEA limitations are formulated on the basis of attainable effluent concentrations in minimum volumes of water, the treatment plant would most likely meet these limitations if the flow were as low as possible. Lower flows would obviously reduce the cost of the facility. Additionally, and more importantly, the flow volume must be such that it would be attractive to industry vis-a-vis in-plant treatment. All things considered, the most likely design basis is the BATEA load limitations in 466,000 cu m/day (123 mgd) (10 % of presently discharged process and unsegregated cooling water) and a design flow rate of 568,000 cu m/day (150 mgd). The extra 102,000 cu m/day (27 mgd) would provide for 1,020,000 cu m/day (270 mgd) of process water use in the Monongahela Valley, assuming that new facilities would segregate non-contact cooling water and discharge only 10% of the process water as blowdown.

The first treatment facility design considered (scheme A) was based upon a flow of 908,000 cu m/day (240 mgd), i.e., the aggregated BPCTCA discharges from the 68 plants; alkaline chlorination and granular activated carbon adsorption were incorporated in addition to sedimentation, precipitation, oil removal, and two-stage bio-oxidation. This design was based upon the use of the BATEA treatment models in the EPA Development Documents for Effluent Guidelines for the Petroleum Refinery and Steel Industries.

A treatment plant cost estimate was made for scheme A based upon unit volume costs taken from ALCOSAN estimates and operating data; the economies-of-scale were not considered in size extrapolations. The estimated cost (\$373 million) was taken to be a

maximum for preliminary evaluation purposes. This exercise showed that the capital costs of the treatment plant must be minimized if the RWT facility is to be economically feasible.

Two alternative treatment plant designs were considered. The influent and effluent loads for design purposes were taken to be as shown in Table 6, with a hydraulic flow of 568,000 cu m/day (150 mgd). No reduction in present loads were assumed other than those of suspended solids and oils. The two alternative treatment schemes evaluated were: (1) the use of powdered activated carbon with adapted mutant bacteria and sand filtration and (2) a modified version of scheme A utilizing alkaline chlorination and granular activated carbon.

Cost estimates were made for the two treatment alternatives. The capital cost of alternative 1 was estimated at \$156 million (\$1977); the capital cost of alternative 2 was estimated at \$208 million (\$1977). The annual costs of alternative 1 would be higher than for alternative 2 if the powdered activated carbon were used on a through-away basis. Regeneration of the powdered activated carbon appeared to make the costs of the two alternatives essentially equal.

The scheme A design contemplated alkaline chlorination following primary precipitation and clarification. Since the influent cyanide concentration would be expected to be about 1.5 mg/l and the reported maximum is 4 times that, the alkaline chlorination step is probably not needed. The conventional municipal activated sludge plant can tolerate up to 2 mg/l cyanide. Adapted mutant bacteria, as would be used here, can tolerate 25 mg/l or more. Elimination of alkaline chlorination would eliminate mixing basins and secondary sedimentation basins included in scheme A.

The recent work reported by Amoco Oil Company and Standard Oil Company Industrial Wastes, July/August, 1977 (pp. 30 - 35) indicates that a single stage activated sludge plant using powdered activated carbon and sand filtration can match or exceed the performance to be expected from separate final carbon adsorption. Operating conditions were reported as follows:

Aeration Zone Volume	36.7 liters
Settling Zone Volume	5.6 liters
Nominal Flow Rate	3.45 liters/hr.
Nominal Hydraulic Retention Time	15.0 hours
Nominal Settling Time	2.33 hours
Air Flow Rate	200 liters/hr.

pH	6 - 8.5
Caustic Addition Rate	0.12 - 0.30 liters/hr.
Phosphorous in Feed	3 mg/liter
Temperature	Ambient
Activated Carbon Dosage	25 - 100 mg/liter

In view of the uncertainties as to the allowable and the attainable concentrations of pollutants in the RWT effluent, a number of treatment chain alternatives were considered as shown in Figure 5 and as tabulated in Table 17.

The capital and operating costs for each component of the alternative treatment chains were calculated as shown in Table 18 in 1977 dollars; the corresponding Engineering News Record Construction Cost Index was 2600 in 1977. Costs were based upon ALCOSAN construction costs in 1946 and 1973 and ALCOSAN operating costs in 1975 where possible. Other costs were taken from Klemetson and Grenney (73) and the EPA Manual for Upgrading Wastewater Treatment Plants (74).

In Table 19, the total annual costs for each treatment chain alternative are shown. In Table 20, the totals of the BATEA allowable loads are shown based upon the previously published EPA guidelines, together with the attainable RWT effluent loads. In Table 21, the allowable and achievable loads and concentrations are compared. The RWT effluent at 567,750 cu m/day (124 mgd) could probably meet the limitations for most of the pollutants.

For the other pollutants, the required effluent concentrations to meet BATEA, the achievable concentrations, and the USPHS Drinking Water Standards are compared as follows:

ACHIEVABLE, BATEA, AND DRINKING WATER STANDARDS CONCENTRATIONS

Pollutant	Concentrations, mg/l		
	BATEA required	achievable	USPHS standard
Sulfide	0.02	2.30	No Standard
Lead	0.004	0.06	0.05
Diss. Iron	0.06	0.20	0.20 (1)
Tin	0.04	0.90	No Standard
Chromium	0.003	0.05	0.05
Hex. Chromium	0.0002	0.01	0.05

(1) Allowable if Mn = 0.10. (Fe + Mn) must not exceed 0.30 mg/l.

TABLE 17. RWT TREATMENT PLANT ALTERNATIVES

Treatment train unit	A	B	C	D	E	F	G	H
1. Trash rack and Grit Chamber	X		X	X	X			
2. Well and Pumping Station	X	X	X	X	X	X	X	X
2a. Oil Removal		X				X	X	X
3. Chemical Addition	X	X	X	X	X	X	X	X
4. Precipitation and Sedimentation	X	X	X	X	X	X	X	X
4a. Oil Removal	X		X	X	X			
4b. Filtration and Sludge Disposal	X	X	X	X	X	X	X	X
5. Deep-bed Sand Filtration			X	X	X	X	X	X
6. Alkaline Chlorination, 1st sta	X	X						
7. 2nd stage Chlorination and Clarif.	X	X						
8. Powdered Carbon Addition			X	X	X	X	X	X
9. Mutant Bacteria Addition			X	X	X	X	X	
10. Activated Sludge, 6-hr, 2-stage	X	X						
11. Activated Sludge, 13-hr, 1-stage			X	X	X	X	X	X
12. Clarifier, 2.3 hours			X	X	X	X	X	X
13. Clarifier, 4.0 hours	X	X						
14. Sludge Digestion	X	X	X	X		X		
15. Deep-bed Sand Filtration	X	X	X	X	X	X	X	X
16. Granular Carbon Filters	X	X						
17. Furnace Carbon Regeneration	X	X		X				
18. Wet Air-Oxidation					X		X	X
18a. Carbon Regeneration					X		X	X
18b. Waste Bio Sludge Disposal					X		X	X
19. Other Facilities	X	X	X	X	X	X	X	X
20. Interceptor System	X	X	X	X	X	X	X	X

TABLE 18. RWT FACILITY COMPONENT COSTS (\$1977)

Figure 1		Capital cost (total)	Annual O & M cost	50-year depreciation and interest	50-year average annual cost
1.	Trash Racks and Grit Chamber	\$ 4,355,000	\$ 260,000	\$ 169,000	\$ 429,000
2.	Wet Well and Pump Station	\$ 6,045,000	\$ 361,000	\$ 234,000	\$ 595,000
3.	Chemical Addition (in 4)	-	-	-	-
4.	Precipitation and Sedimentation	25,721,000	\$ 1,535,000	\$ 997,000	\$2,532,000
4b.	Vacuum Filtration	\$ 6,149,000	\$ 367,000	\$ 238,000	\$ 605,000
5.	Deep-Bed Sand Filters	\$ 16,129,000	\$ 1,761,000	\$ 625,000	\$2,386,000
6.	Alkaline Chlorination (in 7)	-	-	-	-
7.	Alkaline Chlorination	\$ 26,872,000	\$ 1,603,000	\$ 1,041,000	\$2,644,000
8.	Powdered Activated Carbon (10%)	-	\$ 376,000	-	\$ 376,000
9.	Mutant Bacteria	-	\$ 986,000	-	\$ 986,000
10.	Activated Sludge, 2-stage	\$ 63,471,000	\$ 3,629,000	\$ 2,460,000	\$6,089,000
11.	Activated Sludge, 1-stage	\$ 58,155,000	\$ 3,629,000	\$ 2,254,000	\$5,883,000
12.	Clarifier (in 11)	-	-	-	-
13.	Clarifier (in 10)	-	-	-	-
14.	Sludge Digestion	\$ 6,194,000	\$ 370,000	\$ 240,000	\$ 610,000
15.	Deep-Bed Sand Filters	\$ 16,129,000	\$ 1,761,000	\$ 625,000	\$2,386,000
16.	Granular C (with 17)	\$ 21,622,000	\$ 1,946,000	\$ 838,000	\$2,784,000
17.	Furnace Regeneration	\$ 10,781,000	\$ 1,761,000	\$ 418,000	\$2,179,000
18.	Wet Air-Oxidation	\$ 7,109,000	\$ 1,375,000	\$ 276,000	\$1,651,000
19.	Other Facilities	\$ 21,132,000	\$ 1,261,000	\$ 819,000	\$2,080,000
20.	Interceptor Sewer System	\$ 111,000,000	\$ 1,306,000	\$ 4,301,000	\$5,607,000

TABLE 19. RWT TREATMENT PLANT ALTERNATIVES - TOTAL ANNUAL COSTS

Treatment train unit	A	B	C	D	E	F	G	H
1. Trash Rack and Grit Chamber	0.42		0.43	.43	.43			
2. Wet Well and Pumping Station	.60	.60	.60	.60	.60	.60	.60	X
2a. Oil Removal	X	X				X	X	X
3. Chemical Addition	X	X	X	X	X	X	X	X
4. Precipitation and Sedimentation	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
4a. Oil Removal	X		X	X	X			
4b. Filtration and Sludge Disposal	.61	.61	.61	.61	.61	.61	.61	.61
5. Deep-bed Sand Filtration			2.39	2.39	2.39	2.39	2.39	2.39
6. Alkaline Chlorination, 1st stage	X	X						
7. 2nd stage Chlorination and Clarif.	2.64	2.64			.38	3.76	.38	.38
8. Powdered Carbon Addition			.99	.99	.99	.99	.99	.99
9. Mutant Bacteria Addition			3.76					
10. Activated Sludge, 6-hr, 2-stage	6.09	6.09	5.88	5.88	5.88	5.88	5.88	5.88
11. Activated Sludge, 13-hr, 1-stage			X	X	X	X	X	X
12. Clarifier, 2.3 hours	X	X						
13. Clarifier, 4.0 hours	.61	.61	.61	.61	.61	.61	.61	.61
14. Sludge Digestion	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39
15. Deep-bed Sand Filtration	2.78	2.78						
16. Granular Carbon Filters	X	X						
17. Furnace Carbon Regeneration			2.18					
18. Wet Air-Oxidation					1.65		1.65	1.65
18a. Carbon Regeneration					X		X	X
18b. Waste Bio Sludge Disposal					X		X	X
19. Other Facilities	2.08	2.08	2.08	2.08	2.08	2.08	2.08	2.08
20. Interceptor System	5.61	5.61	5.61	5.61	5.61	5.61	5.61	5.61
Total Annual Costs (\$ million)	26.39	25.94	27.83	26.63	25.49	27.40	25.06	23.52
Total Costs (\$ per million gals.)	482	473	508	486	466	500	458	430

TABLE 20. TOTAL BATEA EFFLUENT LIMITATIONS (9) AND RWT ACHIEVABLE EFFLUENT LOADS

Parameter	Limitation on achievable RWT effluent concentration	RWT effluent, #/day		
		124 mgd	150 mgd	BATEA
Suspended Solids	mg/l from sand filters, use 4 mg/l (1)	4,139	5,007	3,926
Oil and Grease	1-5 mg/l from sand filters + carbon, use 3 mg/l (1)	3,104	3,755	2,134
Ammonia	0.1 mg/l residual after chlorination at pH 7.8 (2)	103	125	760
Phenol	Analytically detectable limit, 0.01 ppm (3)	10.3	12.5	168
Cyanide A	0.01 mg/l achievable by chlorination (4)	10.3	12.5	23.4
BOD	3 mg/l achievable based upon oil concentration	3,104	3,755	782
Sulfide	Solubility limit of FeS = 6.2 mg/l = 2.3 mg/l S---(5)	2,390	2,879	24.1
Fluoride	1.0 mg/l achievable for likely Fl sources (6)	1,035	1,252	1,425
Manganese	Solubility limit = 0.1 mg/l (7)	103	125	77.2
Nitrate	0.5 mg/l achievable by biological denitrification (8)	517	626	1,010
Zinc	0.05 mg/l achievable (4)	51.7	62.6	71.0
Lead	Present average discharge (67#/day)	67.0	67.0	3.9
Diss. Iron	Solubility limit = 0.2 mg/l (7)	302	251	57.9
Tin	Solubility limit = 0.9 mg/l (7)	2,932	1,127	37.0
Chromium	0.05 mg/l achievable (4)	51.7	62.6	3.5
Hex. Cr.	0.01 mg/l achievable (4) = detectable limit (3)	10.3	12.5	0.21

- (1) Attached references on oil and solids removal.
 (2) White, "Handbook of Chlorination," Van Nostrand Reinhold Co. (New York), 1972, p. 472.
 (3) "Standard Methods," 13th Edition (1971), p. 508, p. 157.
 (4) EPA, Development Document for Electroplating Industry, (EPA-440/1-74-003a), p. 74.
 (5) Handbook of Chemistry and Physics.
 (6) EPA, Treatment and Recovery of Fluoride Industrial Wastes, March, 1974 (EPA-660/2-73-024), p. 1.
 (7) Smith, A.E., Analyst, 1973, pp. 65 and 209.
 (8) EPA, Process Design Manual for Nitrogen Removal, October, 1975 (Section 5).
 (9) Based upon published Guidelines remanded to by EPA by the Courts.

TABLE 21. BATEA AND ACHIEVABLE RWT LIMITATIONS

Parameter	RWT effluent loads, #/day		RWT effluent con., mg/l		+/- BATEA
	BATEA	achievable	BATEA	achievable	
Suspended solids	3,926	4,139	3.79	4.00	+
Oil and grease	2,134	3,104	2.06	3.00	+
Ammonia	760	103	0.73	0.10	-
Phenol	168	10.3	0.16	0.01	-
Cyanide A	23.4	10.3	0.02	0.01	-
BOD	782	3,104	0.76	3.00	+
Sulfide	24.1	2,390	0.02	2.30	+
Fluoride	1,425	1,035	1.38	1.00	-
Manganese	77.2	103	0.07	0.10	+
Nitrate	1,010	517	0.98	0.50	-
Zinc	71.0	51.7	0.69	0.05	-
Lead	3.9	67.0	0.004	0.06	+
Diss. iron	57.9	202	0.06	0.20	+
Tin	37.0	932	0.04	0.90	+
Chromium	3.5	51.7	0.003	0.05	+
Hex. Cr.	0.21	10.3	0.0002	0.01	+

SECTION 9

IMPLEMENTATION PLAN

MONONGAHELA VALLEY REGIONAL INDUSTRIAL WASTEWATER AUTHORITY

This plan will outline the steps which must be undertaken in order to establish a RWT facility which would serve the industrial plants along the Monongahela River from the "point" at Pittsburgh to Allenport.

Treatment Plant and Interceptor Sewer System

The treatment plant design is based upon a design flow of 567,750 cu m/day (150 mgd) and the acceptance of not more than 10% of the present discharge of unsegregated process and cooling water. Presently segregated non-contact cooling water would be discharged to the river as is now done. The presently expected average flow to the facility would be 457,826 cu m/day (123.6 mgd). New facilities would be required to segregate non-contact cooling water and discharge to the RWT system not more than 10% of the process water used.

The treatment to be provided is difficult to determine at this time. Under the 1972 Amendments to the Federal Water Pollution Control Act as administered through the NPDES permit system, by 1983 the RWT effluent could contain not more than the total of the effluent loads allowed each plant under BATEA limitations. The BATEA Effluent Limitation Guidelines and New Source Performance Standards are not in effect, having been remanded to EPA by the courts. Additionally, Section 301(C) of the Act provides that the EPA administrator may modify BATEA limitations on the bases of the application of maximum technology, economic factors, and demonstrated progress toward the goal of pollutant discharge elimination. That section is reproduced below:

- "(C) The Administrator may modify the requirements of subsection (b) (2) (A) of this section with respect to any point source for which a permit application is filed after July 1 1977, upon a showing by the owner or operator of such point source satisfactory to the Administrator that such modified requirements (1) will represent the maximum use of technology within the

economic capability of the owner or operator; and (2) will result in reasonable further process toward the elimination of the discharge pollutants.

Assuming that BATEA limitations are established in one way or another for an RWT facility serving the 68 plants on the Monongahela River, and that one or another of the treatment chain alternatives could achieve such limitations, the other steps toward implementation are mutually dependent.

Application for NPDES Permit

The procedure involved here is complex because of the uncertainties outlined in the preceding section, and because all other steps are dependent upon the issuance of a satisfactory NPDES permit. An NPDES application presupposes, at a minimum, that there is an organization which would build and operate the facility, that the discharge point to the surface waters is known, that the volume of wastewater is known, and that there is a treatment system design for specified effluent loads.

Commitment of Potential Users

In order to determine whether or not the potential industrial users would in fact use the RWT facility, the letter and questionnaire shown in Appendix A was sent to 9 present dischargers who account for 85% of 467,826 cu m/day (123.6 mgd) expected flow. Only one questionnaire was returned. Follow-up calls indicated that there was little or no interest in the concept, principally because the costs were considered to be too high, and also because a long-term commitment would be required. The objection to a long-term commitment was based upon the possibility that production units or even entire plants might be abandoned before the facility cost would be amortized.

Obviously without the prior commitment of most of the potential industrial users, such a facility would not be feasible. New technology, changes in regulations, etc. might alter the circumstances. As of now, however, nothing further can be done. The remaining steps toward implementation are given below, assuming that the industry attitude might change.

Application for Other Required Permits

Applications for Pennsylvania Department of Environmental Resources permits would include a Water Quality Management Permit, a Water Obstruction Permit, and a Pollution Incident Prevention Plan. Also required would be a Department of the Army, Corps of Engineers Permit for Activities in Waterways. These permit applications would have to be coordinated with the NPDES permit application.

Institutional Arrangements

Considering the operational history of ALCOSAN in the study area, the existence of an interceptor sewer system to about mile 11.0 on the Monongahela River, and the interest that ALCOSAN may have in reducing or eliminating industrial discharges to its sanitary system, ALCOSAN is the logical agency to build and operate the RWT facility. It would seem that economies could be effected in utilizing the present administrative, engineering, and maintenance personnel; in consolidating purchases; and in utilizing existing rights-of-way. This assumes, of course, that there are no legal, political, or other barriers to this arrangement.

Land Acquisition

With the cooperation of Mr. Richard M. Cosentino of the Southwestern Pennsylvania Regional Planning Commission (SPRPC), alternative treatment plant sites were located. Sites considered were:

1. Under and/or adjacent to the Glenwood Bridge.
2. The blast furnace department of J & L Steel Corporation on 2nd Avenue.
3. East Carson Street near Becks Run.
4. The Chartiers Creek Basin.
5. In the vicinity of Brunot Island, possible the back channel of the river.

The possibility of a plant site providing a recreational area should at least be considered. Underground construction could be a significant factor. The nature of the wastewater to be treated, the treatment processes to be used, and the quality of the effluent to be produced should make the possibility of a swimming or a fishing lake at least worthy of consideration.

Financing the Project

There seems to be little doubt that a municipal bond issue payable from revenues received from the users would be the preferred financing method. If ALCOSAN were to be the operating entity, the mechanism of the bond issue would be considerably simplified, since such an issue would be similar to past issues of ALCOSAN.

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October 6, 1977

APPENDIX

INDUSTRIAL USERS' QUESTIONNAIRE

Dear -----:

Some time ago we contacted you by letter and/or by telephone concerning the study Datagraphics is conducting, i.e., "A Study of the Feasibility of a Joint Regional Industrial Waste Treatment Facility." We solicited suggestions and comments from all of the potential users of such a facility along the Monongahela River from the Point to Allenport.

In general, those contacted said that they could offer no opinions as to whether or not they would be interested in participating until they knew the cost to their particular plants. Accordingly, we have developed cost estimates for a 150 mgd treatment plant served by a 50-mile interceptor sewer system. The capacity is based upon the concept that each plant would recirculate and re-use presently non-segregated process and cooling water and discharge a 10% blowdown to the regional system. Presently segregated non-contact cooling water would be discharged to the river.

The treatment plant, designed to discharge pollutant loads equal to the total BATEA loads from all plants, would cost \$157 - \$198 million and the sewer system about \$111 million. The total system would thus cost \$268 - \$309 million. To put this in perspective, we estimate that it would cost \$407 million to build the 180 mgd ALCOSAN system at 1977 prices.

At a total cost of \$300 million, the RWT facility operated by an Industrial Development Authority and financed by revenue bonds would cost about \$30 million per year to operate on the average over 40 years. The cost of treatment would thus be about \$548 per million gallons. The estimated user charges are shown in Table II taken from a progress report for this study. These estimates are based upon the data of Table 6 from the same report. The capital charges are based upon a bond issue patterned after a recent Beaver County issue. Other operation and maintenance costs are estimated at \$14.399 per year.

We are of the present opinion that such a regional facility is technically and economically feasible. The economic feasibility depends, of course, upon the decisions of the potential users, i.e., you and your industrial counterparts. No one else can do more than speculate as to whether or not industry would find the concept attractive.

Although costs are of primary importance, we have been surprised to find that most of those contacted have not expressed interest in the other benefits which we believe should be of at least equal interest. Other benefits to be considered, in our view at least, are:

1. Freedom from NPDES sampling monitoring, inspection and reporting (except for non-contact cooling water outfalls).
2. Virtual freedom from the chances of NPDES Permit violations.
3. No additional capital outlays for BATEA limitations (except for sewer connections).
4. No added labor, supervision or management time, and no additional space or utility requirements for BATEA limitations.
5. BATEA costs would be all chargeable as operating expenses.
6. Availability of a receptor for wastewaters from new facilities.
7. A good public relations image, and a real contribution to the future of water-using industries in the Monongahela Valley.

We believe that the following paragraph summarizes many of the tangible and intangible benefits.

"Wastewater treatment plant operation is regarded by industry as a necessary, but distracting interference with the primary production operations. Operators must be hired and trained, management time must be allotted, and the treatment system must be operated to meet strict effluent limitations day in and day out in the face of severe penalties for non-compliance. BPCTCA limitations can be met with a minimum of such problems, but BATEA limitations require much more effort and dramatically increase the potential for violation of effluent limitations due to equipment malfunctions and operator error. The centralized plant incorporating treatment beyond anything feasible in-plant, utilizing more highly skilled personnel whose only concern is wastewater treatment, and providing means to assimilate and even out occasionally high contaminant loads can only result in uniformly better treatment in total."

We have no wish to burden you with involved questionnaires, but we do need some sort of definable and reportable industry reaction to this proposal if any good is to come of the study. We are therefore asking you to take a few minutes and answer the enclosed short list of questions. We would, of course, be delighted if you want to expand your comments and we would like to meet with you for detailed discussions if you would be willing.

We shall look forward to hearing from you.

Best regards.

Sincerely yours,

Henry C. Bramer, President
(Project Grant Director)

HCB/rlf

cc: Interested Project Staff
and Management.

JOINT REGIONAL INDUSTRIAL WASTE TREATMENT FACILITY

Potential Users Questionnaire Form

1. Do you want your answers kept anonymous? Yes _____ No _____
2. Name _____ Co. or Plant _____
Address _____ Telephone _____
3. Are there corrections to Table 6? Indicated on Xerox copy _____
None _____
4. Do you find the concept of an RWT facility attractive? Yes _____ No _____
5. Are the estimated costs: Too high? _____ Acceptable _____ Unacceptable? _____
Higher than for in-plant treatment? Other? _____
6. Would your company be likely to participate? Yes _____ No _____ Doubtful _____
7. If no or doubtful in 6, why? _____

8. How do you value the following benefits of an RWT facility?
 - a. No NPDES sampling, etc. _____
 - b. No NPDES violations _____
 - c. Minimize BATEA capital outlay _____
 - d. No added in-plant BATEA treatment _____
 - e. Labor _____ Supervision _____ Training _____ Management _____
Space _____ Utilities _____ Other _____
 - c. BATEA costs would all be expense items _____

- d. Provision for new facility discharges _____
- e. Public Relations _____
- f. Better treatment _____ Reliability _____
- g. Costs more important than: a _____ b _____ c _____ d _____ e _____ f _____ h _____
- h. Do you see any other benefits, advantages, or disadvantages to the RWT concept? No _____ What are they? _____

9. Is the Public Authority Operation acceptable? Yes _____ No _____ Don't Care _____
If no: What other? _____

User-owned? _____ Private Utility? _____
10. Is the low-interest rate on revenue bonds attractive? Yes _____ No _____
Don't Care _____
11. Please comment here or attach other comments, suggestions, data, etc.

12. Should we contact anyone else in your company or plant? No _____

Name _____ Telephone _____

Address _____

13. Would you like to arrange a meeting? Yes _____ No _____

Where _____ When _____

Will Call _____ Call Us _____

14. Do you want any additional information? Yes _____ No _____

What information do you want? _____

TABLE II. ANNUAL CHARGES FOR MAJOR DISCHARGERS USING RWT FACILITY

Plant name and location	% of total discharge (1)	user charge/year
J & L Steel Corp., Pittsburgh	17.42	\$5,226,000
Mesta Machine Co., W. Homestead	0.04	12,000
U.S. Steel Corp., Homestead	9.23	2,269,000
U.S.S., Corrie Furnace, Rankin	7.10	2,130,000
U.S.S., Edgar Thompson, N. Braddock	19.00	5,700,000
U. S. Steel Corp., Duquesne	10.55	3,065,000
U.S.S., National, McKeesport	0.32	96,000
U.S.S., Christy Park, McKeesport	0.02	6,000
U.S.S., Irvin, W. Mifflin	4.85	1,455,000
Copperweld Steel Co., Glassport	0.09	27,000
Textron (Pittroa), Glassport	0.03	9,000
U. S. Steel Corp., Clairton	9.18	2,754,000
American Chain And Cable, Monessen	0.01	3,000
Wheeling-Pittsburgh, Monessen	4.72	1,416,000
Corning Glass, Charleroi	0.16	48,000
Wheeling-Pittsburgh, Allenport	1.99	597,000
Other	15.29	4,587,000
Totals	100.00	\$30,000,000

(1) Process water and non-segregated cooling water only.

Company	total annual charge	% of total
J & L Steel Corp.	\$ 5,226,000	17.42
U.S. Steel Corp.	18,075,000	60.25
Wheeling Pittsburgh Steel Co.	2,013,000	6.71
Mesta Machine Co.	12,000	0.04
Copperweld Steel Co.	27,000	0.09
Textron (Pittron)	9,000	0.03
American Chain and Cable Co.	3,000	0.01
Corning Glass Co.	48,000	0.16
Other	4,587,000	15.28

TABLE 6. PRESENT MAJOR DISCHARGES - PERCENTAGES OF TOTAL FLOW

Plant name and location	Average total flow mgd	Average cooling water mgd	Average net mgd	% of total net
J & L Steel Corp., Pittsburgh	330.3	114.9	215.4	17.42
Mesta Machine Co., W. Homestead	2.32	1.87	0.51	0.04
U.S. Steel Corp., Homestead	128.0	13.82	114.18	9.23
U.S., Corrie Furnace, Rankin	180.0	92.16	87.84	7.10
U.S.S., Edgar Thompson, N.Braddock	234.9	0	234.9	19.00
U.S. Steel Corp., Duquesne	130.4	0	130.4	10.55
U.S.S., National, McKeesport	38.61	34.61	4.0	0.32
U.S.S., Christy Park, McKeesport	0.227	0	0.23	0.02
U.S.S., Irvin, W. Mifflin	60.0	0	60.0	4.85
Copperweld Steel Co., Glassport	1.17	0.10	1.07	0.09
Textron (Pittroa), Glassport	0.519	0.173	0.35	0.03
U.S. Steel Corp., Clairton	133.1	19.57	113.53	9.18
American Chain And Cable, Monessen	0.100	0	0.100	0.01
Wheeling-Pittsburgh, Monessen	58.31	0	58.31	4.72
Corning Glass, Charleroi	2.67	0.73	1.94	0.16
Wheeling-Pittsburgh, Allenport	32.2	7.63	24.57	1.99
Other	<u>189.11</u>	<u>0</u>	<u>189.11</u>	<u>15.29</u>
Totals	1522.0	285.56	1236.44	100.0